FEBRUARY 2, 1959 Price 50 cents

# Product Engineering

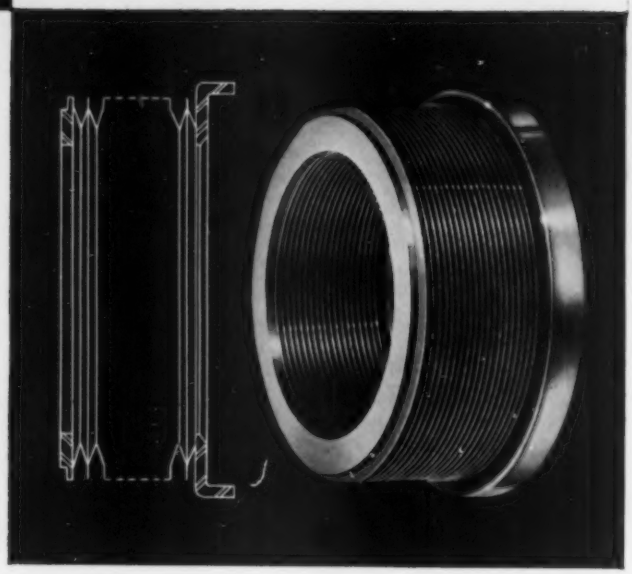
McGRAW-HILL MAGAZINE OF DESIGN
RESEARCH AND DEVELOPMENT

**Spectrum of Power...**

*see page 5*

C/R DESIGN NOTES

# How C/R's New Metal Bellows Seal Meets Seemingly Impossible Operating Conditions



## Operating Ranges

| | |
|---|---|
| Temperature | −400° to 1000° F. |
| Pressure | 500 psi |
| R.P.M. | 80,000 plus |

These known operating ranges indicate the function of this seal. It is designed for applications where temperatures and mediums to be sealed forbid the use of any organic materials. Typically, these applications include fuel pumps, compressor power units and turbine starters characteristic in rockets and missiles. Other applications include mechanisms which are exposed to a high level of radioactivity.

## Design Advantages

The C/R metal bellows seal consists of a metal bellows — a welded homogeneous unit which is secured at one end — and a carrier ring in which the sealing face is mounted. The seal does not contact the shaft. It is stationary, and the only rubbing surfaces are the sealing face and mating ring. These surfaces are precision lapped to provide a positive seal with minimum friction. At any given pressure, the seal can be designed to maintain proper and constantly effective face loads. It orients immediately to run-out and will resist any torques it is subjected to in operation. The design has high end-play tolerance: Chicago Rawhide engineers have deflected a bellows .100 in. for three million cycles at 1750 cpm and at a temperature of 500° F. with no adverse effects.

A further advantage is relatively light weight and compactness. The C/R metal bellows seal can be designed for minimum axial and radial space. Axially, complete seals can be produced within a ¼ in. cross-section. Radially, dimensions are comparable with conventional end face seals.

The C/R metal bellows seal can also be designed with an extremely low coefficient of expansion. The importance of this factor becomes apparent with the fact that in many applications the operating temperature may change hundreds of degrees in a very few seconds.

## Mediums To Be Sealed

Virtually any known liquid or gas may be positively sealed with this design, depending upon duration or service life. From a practical viewpoint, the C/R metal bellows seal is the best design for the sealing of cryogenic and high-energy fuels such as LOX, hydrogen peroxide, fluorine and other missile and rocket propellants.

Where possible, lubrication of the two sealing faces is desirable to prolong service life. However, the medium being sealed commonly acts as the lubricant and may be merely hot gas.

## Materials

Sealing faces and mating rings for the C/R metal bellows seal are available in a variety of materials including carbons, carbides, ceramics and various alloyed metals for both high temperature and corrosion resistance. The bellows can be furnished in any of several metals and alloys such as stainless steel, Monel, Inconel X, Ni-Span C and other special alloy steels.

## Consult C/R Engineers

Each application for the C/R metal bellows seal is essentially a custom-design and an intimate knowledge of all conditions to be encountered must be known by Chicago Rawhide engineers to produce the correct combination of properties in the seal. Then, whether you require five, fifty or five thousand seals, Chicago Rawhide will design and produce the correct seal to solve your problem.

***Helpful Design Data:***

*We will gladly furnish you with a design guide and space envelope data concerning the C/R Metal Bellows Seal. Just write for Bulletin MBS-1 on your company letterhead.*

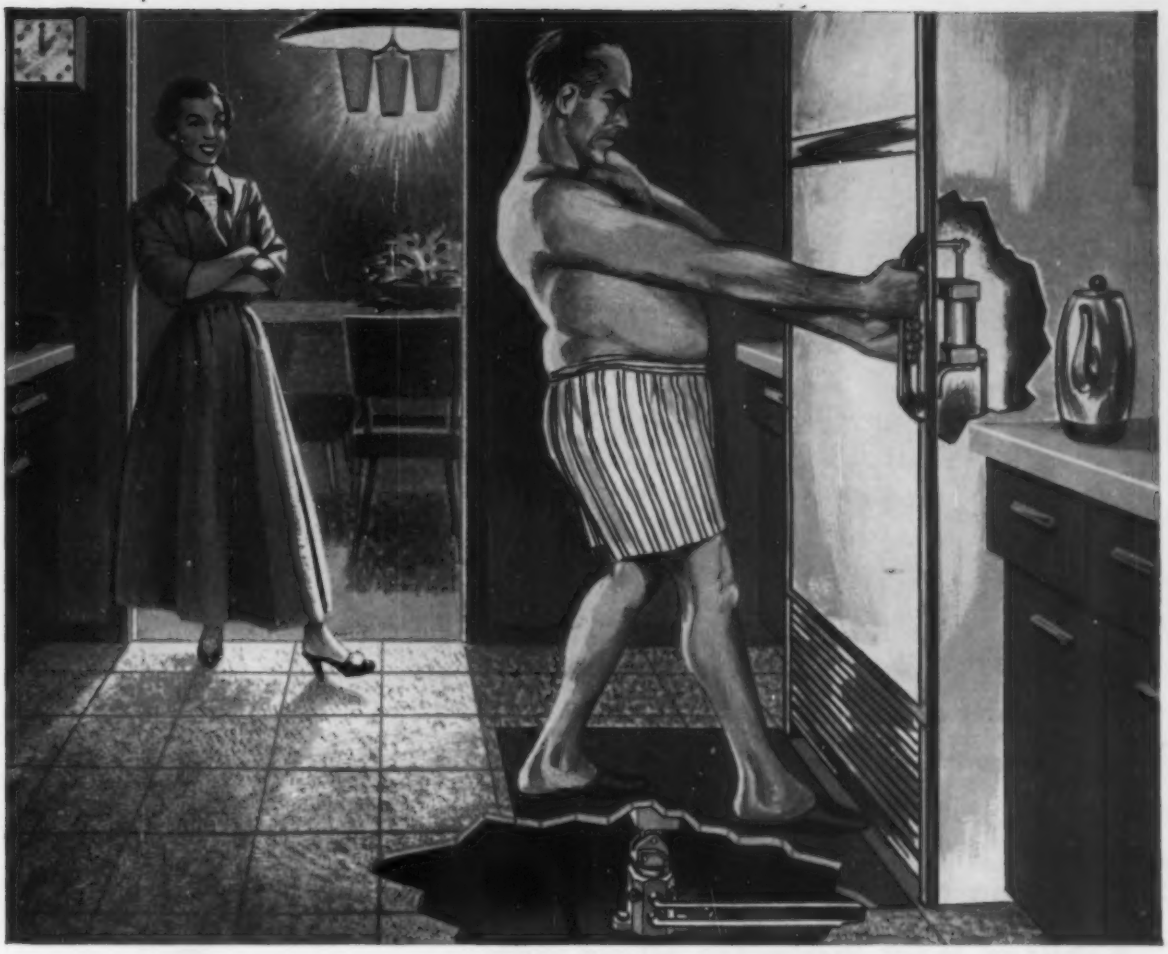
**CHICAGO RAWHIDE MANUFACTURING COMPANY**

1237 Elston Avenue • Chicago 22, Illinois

*Offices in 55 principal cities*

**In Canada:** Chicago Rawhide Mfg. Co. of Canada, Ltd., Brantford, Ontario

**Export Sales:** Geon International Corp., Great Neck, New York



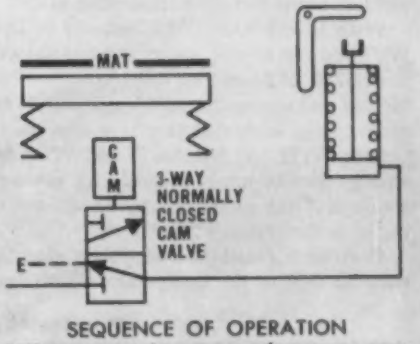
# What? Air Won't Let Him Get Too Fat!

**We admit we are not serious, but . . .**

In a previous moment of strength he has set the controls—now, if he weighs over 200 pounds when he steps on the mat in front of the refrigerator, the door just won't open. But while he is under 200 pounds, no trouble. Now, it's highly unlikely that the refrigerator folks will be mobbed by eager buyers for such a diet-master model, but we have jumped on it as a good chance to show how a cam valve can say "yes" or "no."

**Ross Cam Valves can "think" for your circuits, too**

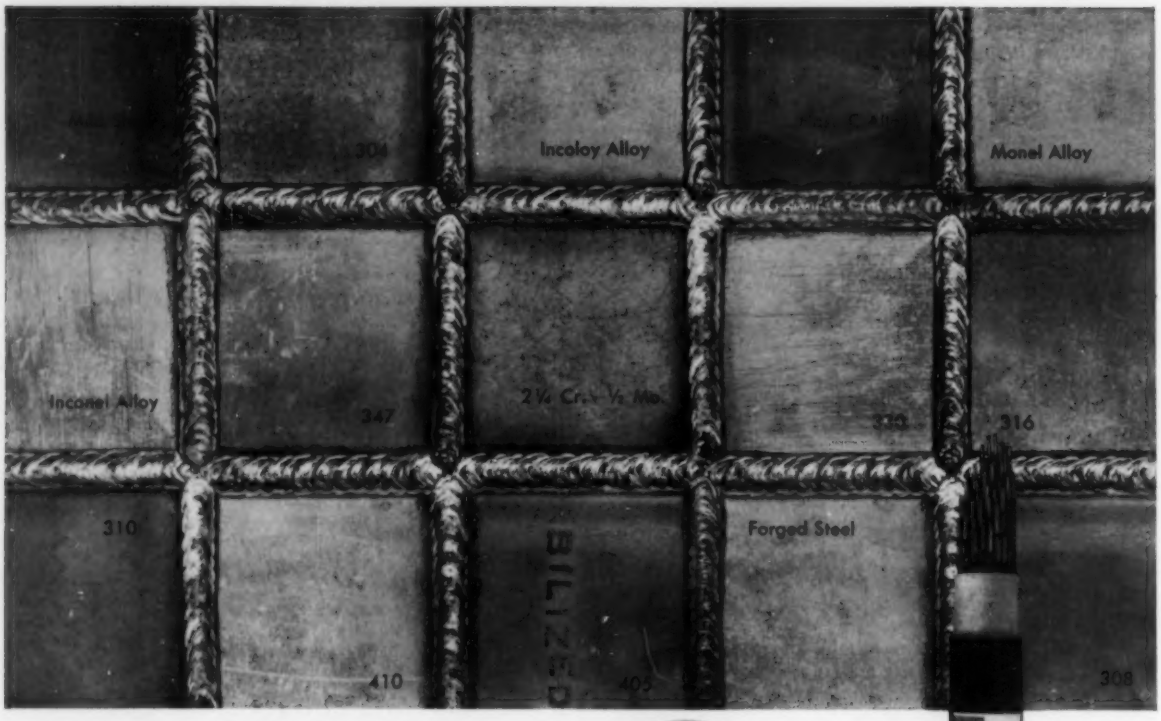
Cam valves are the key to air automation. They can act on almost any mechanical signal to set off . . . or restrict . . . another operation. Then still another cam valve can interlock that circuit with yet further operations and so on until any number of operations can be sequencing one another. Are you realizing the full possibilities from cam valves? The Ross line includes so many models, we invite you to call your Ross representative or write us.




SEQUENCE OF OPERATION

Sufficient weight on mat depresses cam, operating valve and moving cylinder to point where it restrains door handle from opening.

**Ross OPERATING VALVE CO.** 114 E. Golden Gate Ave. • Detroit 3, Michigan




*New freedom of design in welded joints...*

# Now you can get strong welds between most dissimilar alloys with one electrode... one wire... Inco-Weld "A"

No longer do you need to avoid designs involving welded joints between dissimilar alloys.

With Inco-Weld* "A" Electrode or Inco-Weld "A" Wire you can rely on sound production welds in better than 97% of dissimilar alloy combinations involving ferritic and austenitic stainless steels, low alloy steels, mild steels, high nickel alloys and other alloys.

Inco-Weld "A" Electrode and Wire assure you of strong, ductile joints suitable for severe service . . . welds of X-ray quality . . . made without special training or techniques.

Corrosion resistance of joints usually equals or exceeds that of the base metal. With Inco-Weld "A" Wire, the deposit can be age-hardened.

Don't hesitate to design in dissimilar alloys . . . keep Inco-Weld "A" versatility in mind.

For technical data and case history evidence showing how others use Inco-Weld "A" Electrode and Wire successfully, send for folder "Now You Can Weld Dissimilar Alloys." Write The International Nickel Company, Inc., 67 Wall Street, New York 5, N. Y.

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**THE INTERNATIONAL NICKEL COMPANY, INC.**
67 Wall Street — New York 5, N. Y.

**SOME OTHER DISSIMILAR METALS SUCCESSFULLY WELDED WITH INCO-WELD "A" WIRE**

| Plate Material | Thickness | Plate Material | Thickness |
|---|---|---|---|
| 304 to Monel Alloy | .078" | Nickel to SA-285 | .062" |
| 304 to Carbon Steel | .078" | Inconel Alloy to Hastelloy "C" Alloy | .078" |
| Carbon Steel to Monel Alloy | .078" | 10% Ni-Clad-Steel to 10% Ni-Clad-Steel | ¼" |
| Carbon Steel to Inconel Alloy | ⅜" | 3½% Ni-Steel to 3½% Ni-Steel | ½" |

# INCO WELDING PRODUCTS

**electrodes · wires · fluxes**

# Product Engineering

THE McGRAW-HILL MAGAZINE OF DESIGN, RESEARCH AND DEVELOPMENT

FEBRUARY 2, 1959 Vol. 30, No. 5

**5 Steps to Faster Reading** 21 ... The Reading Laboratory Inc
This instalment shows how to improve your vocabulary . . . adjust your reading pace to difficulty of the material . . . acquire the valuable habits of evaluating and summarizing what you read.

**Linkages by Graphical Synthesis** * 40 ... R T Hinkle, Michigan State University
The author's methods simplify design of 4-bar linkages to generate specific functions. Article includes working examples illustrating the three basic problems and how to solve them.

**Copper Alloys for Tubular Parts** 44 ... D S Granniss, The American Brass Co
Easy to handle, small tubing can be shaped to meet many requirements. Here are basics of design with these materials.

A HOW-TO **Self-broaching Shaft for Gears** 47 ... W J Opocensky, Librascope Inc
The same neat method will also key links to small shafts.

**Design Features in New Products** 48 ... Rivets fit closer and go in easier, thanks to variable stroke velocity and pressure of this riveting machine; polishing-deburring machine gives spinning parts a rubdown—inside and out; feature of new transfer-and-drilling machine is single feed unit, with compound movements, that drills and deburrs both ends of hole in one pass.

**Quick Test for Structural Vibrations** 52 ... Wilbur DuBois, Boeing Airplane Co
An oscilloscope tells the story in pictures: shows when resonance occurs, locates trouble spots, indicates what causes them.

SPECIAL REPORT **Reliability of Electrical Connections** 54 ... F D Yeaple, Associate Editor
How do they rate—soldering, crimping, welding, clamping, wrapping and other connector methods? Here are candid comments gathered at the recent Electronic Industries Association conference.

**Plastic Laminates for Punching** 57 ... E C Graesser, National Vulcanized Fibre Co
Selection guide has a chart that relates punching ease of various laminates to their mechanical and electrical properties.

**Product Design for—300 F** * 60 ... P E Loveday, Linde Co, Div Union Carbide Corp
The supercold gases given by liquefied air find increasing industrial use but the job of design gets harder: Materials embrittle . . . moving parts "freeze" . . . lubricants congeal. Here's your introduction to ways of dealing with this new environment.

DESIGN FILE **12 Ways to Retain Gaskets** 64 ... F W Wood Jr, Vitro Laboratories
Design roundup covers bolts, spacer plates, recesses, etc.

**Safe Piston-rod size** 67 ... Z J Lansky, Hannifin Co
Charts for power cylinders give answers for strokes of 10 to 300 in. in five different mounting styles.

DEPARTMENTS

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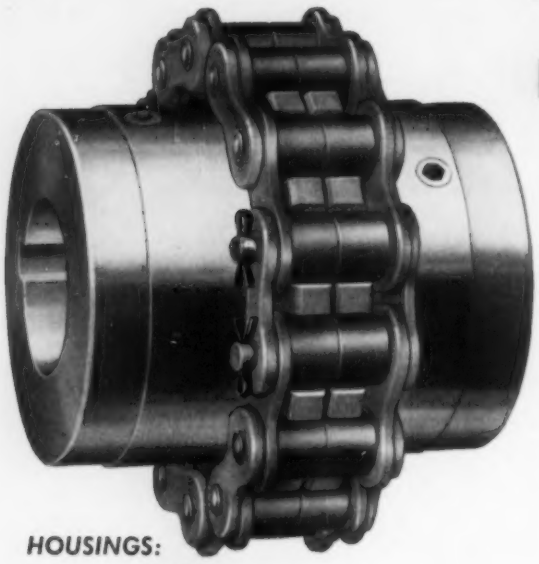
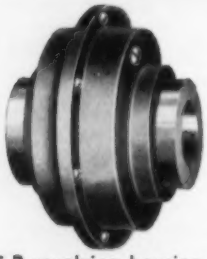
*Why LINK-BELT "RC" spells the* **Right Coupling**

***when you want...***



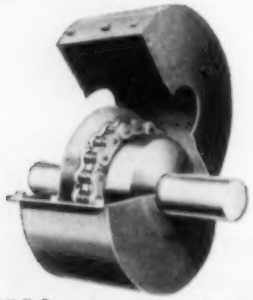
1. Simplicity
2. Low cost
3. Dependability

***HOUSINGS:***



**STYLE R** revolving housing, spun metal, vertical split.

**STYLE P** revolving housing, plastic, horizontal split.



**STYLE S** stationary housing, fabricated steel.

## Exclusive divided roller design gives you all three

Here's a reliable shaft coupling that meets every requirement for economical power transmission. Because the divided rollers make independent contact with each coupling half, Link-Belt "RC" flexible couplings give you *equalized load . . . proper balance at high speeds . . . effective compensation for shaft misalignment.*

Durability is another feature of these *all-steel* couplings. All parts are precision-made and hardened for reliable long life.

Low initial cost . . . easy installation and maintenance . . . dependable performance—they're all yours with Link-Belt "RC" flexible couplings. And they're available in a wide range of sizes for shafts up to 12 inches.

**COMPLETE DETAILS** on Link-Belt "RC" flexible couplings are contained in Folder 2363. Contact your local Link-Belt office for a copy.

**LINK-BELT**

**"RC" FLEXIBLE COUPLINGS**

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# Interesting to Note . . .

1. I-A
2. J33
3. T31
4. J35
5. J47-25
6. J47-17
7. J73-3
8. J79-3

## GE Jets

Before the Wright Brothers could get off the ground 55 years ago, they first had to select a means of propelling their craft. Steam engines were probably the most popular power sources of the day—they spun the propellers of transoceanic ships, drove the shafts that moved some of the horseless carriages, and supplied power to run industry. For a heavier-than-air craft however, a steam engine just weighed too much per horsepower. Other mechanical devices like a spring-wound propeller or an egg-beater crank were all turned down in favor of a small 4-cyl gasoline engine. Because such engines were not readily available, the Wrights designed and built their own. It delivered 12 hp, enough to carry their plane a distance of 120 ft —less than the wingspan of a modern bomber. Winged flight, via gliders, was 20 years old before the Wright Brothers solved the propulsion problems, yet within three years flying machines appeared all over the world.

In 1937, the next major development in aircraft propulsion took place—the jet engine. Although the principle of jet propulsion had been known for centuries, a useful jet could not be developed until high-temperature-resistant metals were available to withstand the terrific heat. When these metals were developed, Air Commodore Frank Whittle, in England, was able to design the first practical jet engine. On our cover are eight General Electric jet engines, and these are some of the planes that incorporate them:

| | | | | | |
|---|---|---|---|---|---|
| 1. | I-A | Bell P-59 | 5. | J47-25 | Boeing B-47 |
| 2. | J33 | Lockheed P-80<br>Bell XP-83 | 6. | J47-17 | NAA F-86D |
| 3. | T31 | Convair XP-81<br>Ryan XF2R-1 | 7. | J73-3 | NAA F-86H |
| 4. | J35 | NAA XB-45<br>Convair XB-46<br>Martin XB-48<br>Republic XP-84<br>Boeing XB-47 | 8. | J79-3 | Lockheed F-104<br>Grumman F11F-IF |

*(Continued on page 7)*

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# Technical data for gasket design and selection

NUMBER NINE

## How to get better sealing at no extra cost in fiber sheet gasket applications

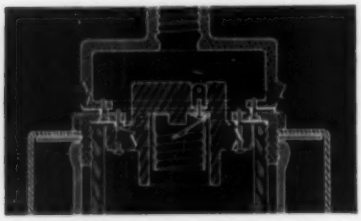
Economy is among the most important design objectives, whether it be an opportunity to reduce costs or a way to improve performance at no increase in price.

A new beater-saturated gasket material—Accopac N-852—is delivering such economy in a variety of applications where conventional plant fiber gaskets have been used.

In every case, N-852 was used at no increase in cost, and in many instances, this new material delivered a substantial bonus in better performance.

Accopac N-852 is made by a process pioneered and patented by Armstrong. In this process, cellulose fibers are combined with a synthetic latex binder and formed into dense, homogeneous sheets of unusual uniformity.

The binder in N-852 cannot be volatilized or extracted in any recommended application. As a result, gaskets cut from this new material will not shrink in use or in storage.



The efficiency of this vapor-tight light fixture was reduced when binder in a conventional plant fiber gasket volatilized and condensed inside globe. The non-extractable binder in N-852 helps eliminate problems of this type.

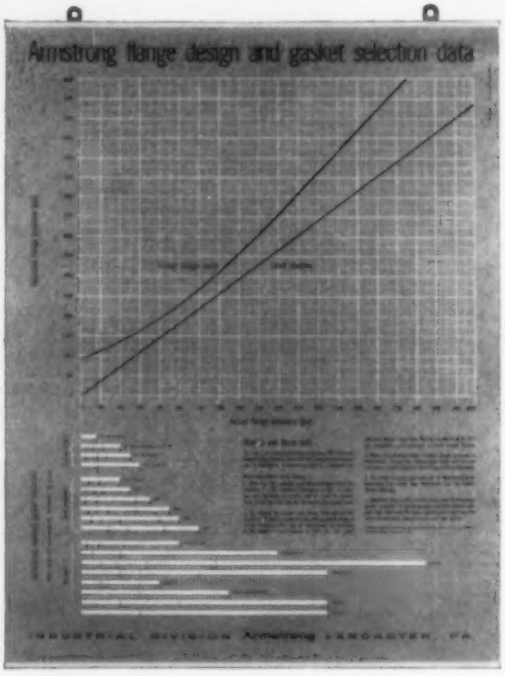
Accopac N-852 is recommended for any sealing job where glue-glycerine saturated materials are now being used. Typical applications are in caps for gasoline tanks and radiators, master cylinders for brakes, gear case covers, and hand hole covers.

N-852 is available in sheets, rolls, or die-cut parts. It can be obtained direct from Armstrong or locally through Armstrong Approved Gasket Fabricators throughout the country. Write to us for more information on Accopac N-852—or a list of Armstrong Approved Fabricators.

## Free wall chart helps assure positive seals and guides in proper gasket selection

Leaks in gasketed joints are at times attributed to such things as compression set or torque loss, when the real problem is simply that the flange load is too low to maintain a seal.

To be sure of adequate unit loads, two things must be considered. The first is the *"seal point"* of the particular gasket material, i.e., the unit pressure required to form a seal. This point is frequently underestimated. It varies widely, even among materials of the same general class.




This 18" x 23" wall chart simplifies flange load calculations and guides in selection of proper gasket material.

The second thing is the *actual* unit load on the gasket, as contrasted with the *apparent* load arrived at mathematically by converting bolt torque to bolt load.

The apparent load and the actual load rarely coincide, because friction on bolt threads results in wide variations in bolt efficiency. Such friction soaks up bolt torque, often to the extent that actual pressure is only a small fraction of pressure anticipated on the basis of bolt torque calculations.

These possible variations in bolt efficiency point up the need for a method of estimating what percentage of the indicated torque load is dissipated in overcoming varying degrees of thread friction.

Research engineers at Armstrong have established by original laboratory procedures the seal points of Armstrong resilient gasket material. In addition, they have developed a simple method of converting apparent flange pressures to actual flange pressures, taking into account a wide range of bolt thread conditions.

This data takes much of the guesswork out of flange load calculations and gasket selection. It gives a designer reasonable certainty of getting loads that will equal or exceed the minimum required for sealing with the various Armstrong materials.

The new method is discussed in detail in the Armstrong Gasket Design Manual, and its major points are consolidated for easy reference on an 18" x 23" wall chart. Copies of the manual and chart are offered at no charge. Please request them on your business letterhead only, addressing your inquiry to Armstrong Cork Company, Industrial Division, 7102 Irvin Street, Lancaster, Pennsylvania.

**Armstrong GASKET MATERIALS**

*. . . used wherever performance counts*

# Interesting to Note . . . . *(continued)*

## Edison's New Year's Party

New Year's Eve, 1879, was the night set by Thomas Edison to invite some people to his laboratory at Menlo Park, NJ, to witness a demonstration of the electric light. Already he had spent several weeks testing and retesting wires, regulators, motors and switches. His reputation was well established but he couldn't afford wiring trouble or some unexplainable mishap. Reporters from New York would record the event for the world; W. E. Chandler, soon to become a New Hampshire senator, would be at the demonstration with Kansas' Senator Plumb; gas company officials and engineers would watch for any flaw which could be used to downgrade the new illumination system.

Several hundred bulbs had been carefully assembled

Credit National Park Service

**Edison's Home and Laboratory at Menlo Park, NJ (Now Edison, NJ) New Year's Day 1880.**

by hand; air was pumped out of each by a special vacuum pump built by Edison. Although the bulbs would burn brightly, they still needed improvement to make them last longer. Notebooks were rechecked, then put away for future reference. Beside many of Edison's notes appeared the capital letters, T. A.–Try Again. To many, Edison's demonstration was like a circus. Reporters, businessmen and curious citizens had heard a lot about this electrical wizard and his laboratory; now they were invited to meet the man and see for themselves just what an electric bulb would do.

What was to be a New Year's Eve demonstration and plant tour lasted a full week. Special trains brought hundreds of interested people who braved stormy weather to see four houses illuminated, several streets lighted and many lamps burning in and around the Edison buildings. To convince the most skeptical, Edison ordered all lab doors kept open and all those working in the lab to answer any and all questions.

For a full week he had no peace, shaking thousands of hands and explaining his invention over and over again. Gas company officials were impressed and a little worried. They told Edison that they could reduce the cost of gas, still make a profit and still compete with his system. Then Edison would mention such innovations as the electric motor, and all its ramifications. The gas people worried anew and asked more specific questions about cost, power and future applications. All questions were answered fully and clearly. If Edison felt an interested party was confused, he'd explain all over again.

The results of Edison's demonstration are obvious today. What was the beginning of a new electrical art is now history. Like Edison, electrical pioneers are still interested in connectors (p. 54), transformers and the problem of making better use of electrical energy. To promote this end, many cities and states have set aside the week of Feb 8 to focus attention upon electricity's role in our daily life.

## Young Man with a Temperature

Had Ponce de Leon ever found his fountain of youth, it is not certain what he would have done with it. For although youth has its advantages, for many it has been a barrier surmountable only by time. When India's great mathematician, Srinivasa Ramaniyan, began his schooling, he was scorned by his classmates and overlooked by his elders. But despite his very limited formal education, he was one of the great minds of mathematics.

Scotsman William Thomson was another genius who made scientific history while still in his teens. Like Ramaniyan, Thomson had scant elementary education–was schooled at home by his father. His mind was so advanced, he passed the entrance exams at the University of Glasgow when he was only 11. At 24, he submitted a paper on an absolute scale of temperature measurement which eventually became known as the Kelvin Scale. In low-temperature design (see p. 60) this scale is now used constantly. By the time he was 26, he had published no less than 50 papers.

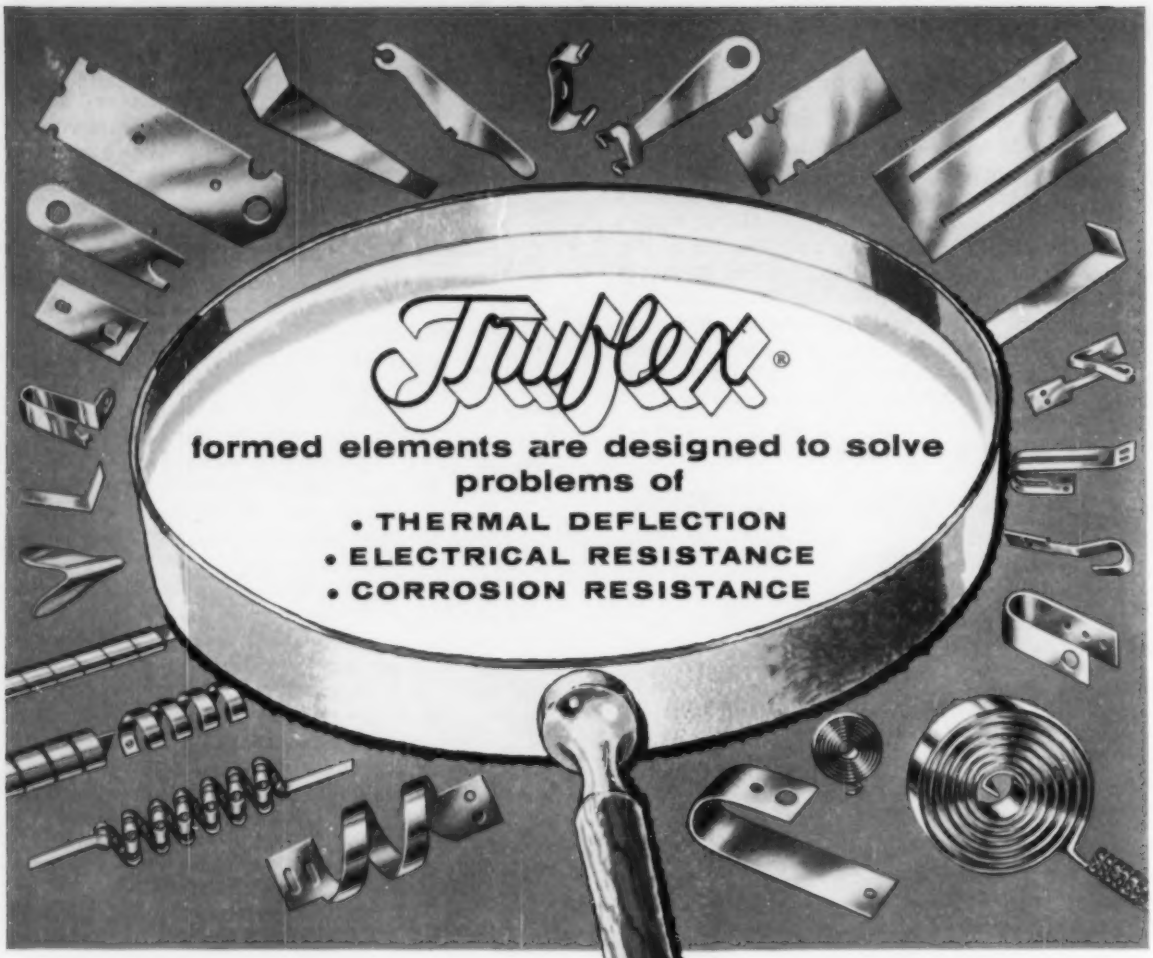
Thomson became involved with the laying of the Atlantic Cable. He designed what may have been the first use of stranded wire in electrical work. For this work he was knighted in 1866 with the title of Lord Kelvin.

## Three Barley Grains to the Inch

It was Plato who said, "We are exposed to many delusions. But reason thus confused by false appearances is beautifully restored by measuring, numbering and weighing." A plea to develop more accurate methods of measuring is still being echoed today by our National Bureau of Standards chief, Dr. Allen V. Astin, p 37. Now, with artificial satellites and planets circling above, we must strive for better and more precise ways to measure. And if more accurate standards do become available they still have to be accepted to achieve validity.

In the past, every nation–and many counties and cities–adopted their own standards. In England under Edward I the legal unit of measure was the Iron Ulna. This, by royal decree, was the distance of three feet. Later, Edward II broke the standard down to the "inch" or one thirty-sixth part of an Ulna. It was further ordained that, "3 grains of barley, dry and round, make an inch; 12 inches make a foot; 3 feet make an ulna; 5½ ulna make a perch; and 40 perches in length and four perches in breadth make an acre." This figure was arrived at simply by measuring how much land a yoke of oxen could plow in a day. Obviously this all depended on the country, the oxen and the time of year. In Scotland, Ireland and several English countries today, an acre still differs according to local customs. In America an acre is legally fixed as 160 sq rods. What's a rod? A 1575 English publication first defined it as, "the total length of the left feet of the first 16 men as they come from Church on Sunday morning."

**–Benedict A Leerburger Jr**




General Plate can furnish Truflex metal parts fabricated to your exacting specifications — or can furnish Truflex to you as strip in coils or flat cut lengths in a wide range of widths and thicknesses.

Either way, you'll get all of the advantages of General Plate's Truflex — a clad metal comprising two or more permanently bonded layers having different coefficients of thermal expansion which will change its curvature when subjected to temperature changes.

Today, hundreds of manufacturers depend on General Plate's years of processing experience for Truflex formed parts that control, compensate and indicate temperature!

***Here's why:***

- **Truflex parts** and subassemblies are engineered to your specifications, ready for installation.
- **Every piece** — in lots of 10 or 10,000 — is a duplicate of the original . . . eliminating rejects and costly assembly adjustments.
- **Production problems,** special equipment, and prolonged experimental work are all eliminated when you use Truflex parts.
- **If you prefer** to make your own parts, Truflex Thermostat Metals are available in extra long coils or flat strips manufactured to your exact specifications.

*Send us a drawing of your thermostat metal parts and let us show you what Truflex Thermostat Metal can do for you.*

**METALS & CONTROLS CORPORATION**

*General Plate Division*

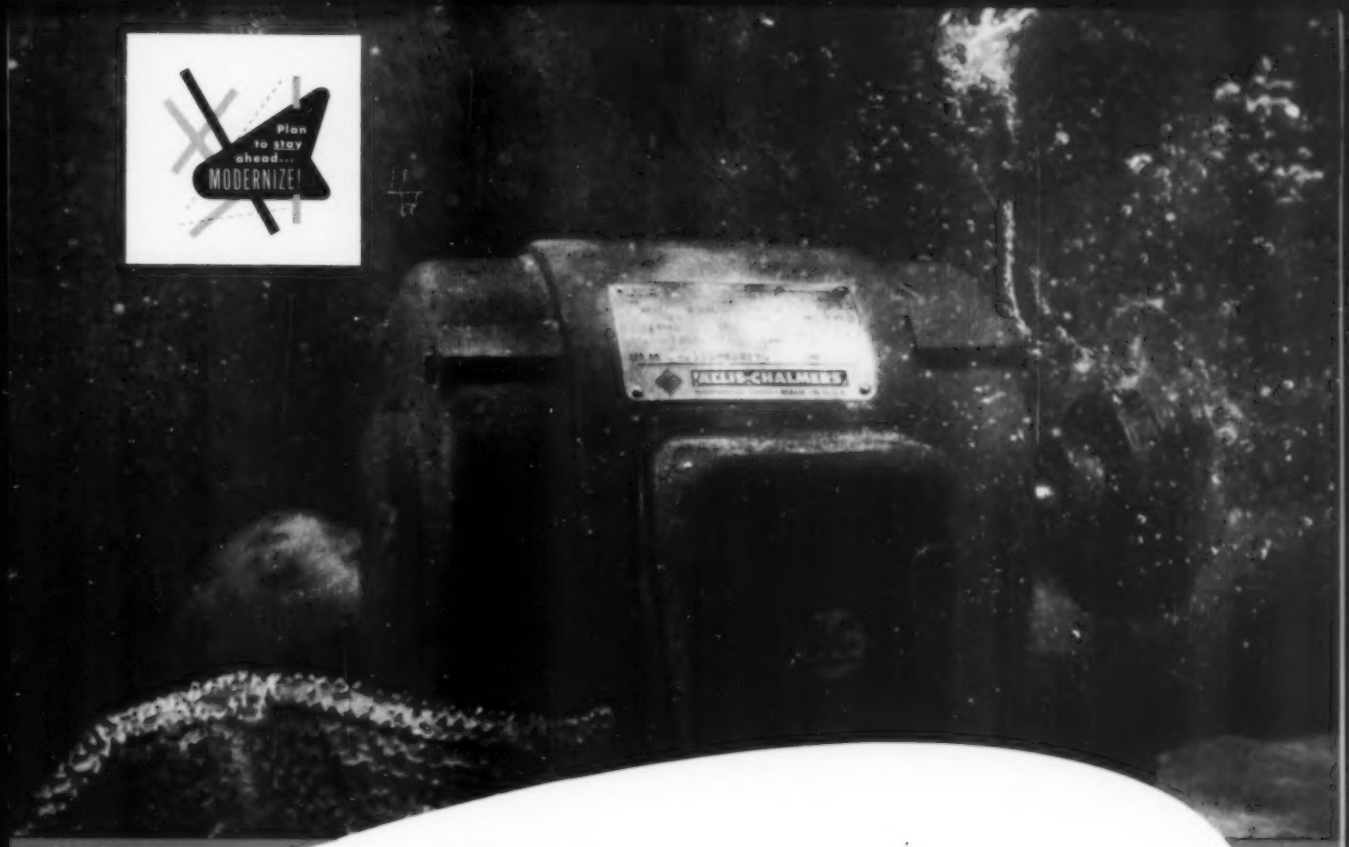
1002 Forest Street, Attleboro, Mass.

FIELD OFFICES: NEW YORK, CHICAGO, DETROIT, INDIANAPOLIS, MILWAUKEE, PASADENA



CIRCLE 104 READER SERVICE CARD

CIRCLE 105 READER SERVICE CARD→




# New motor development obsoletes today's application practices!

**Only from Allis-Chalmers!**

***Super-Seal* motors save up to 60%**

Here's an amazing advance in motor technology! It's the *Super-Seal* motor line—an open motor design so completely unaffected by moisture, dust, dirt, oil, acids and alkalies that it can be used in many applications previously requiring more costly enclosed motors. *Savings range from 15 to 60%.*

*Super-Seal* motor superiority results from two distinct revolutionary insulating techniques. Available in any integral horsepower size, smaller *Super-Seal* motors incorporate a *Poxeal* stator. A durable epoxy resin encloses the stator, creating an electrical system impervious to outside elements.

In larger sizes, *Silco-Flex* insulation is used. In this system, silicone rubber is vulcanized into a homogeneous mass to form a flexible, moisture and heat resistant, void-free dielectric barrier around coils and leads.

Both of these insulation systems are unsurpassed. Proof? An encapsulated motor ran for hundreds of hours at full load in a 4% brine solution.

**Find out more** by reading the next pages; then contact your A-C representative or distributor, or write Allis-Chalmers at address shown on back page.

**ALLIS-CHALMERS**

518 9100

CHRYSLER KIMBERLY-CL ODYEAR

*Two revolutionary insulating techniques developed and pioneered by Allis-Chalmers mean savings of millions of dollars for motor users . . .*

# New open motors are unaffected by moisture and contaminants

**Modern** insulating materials and new methods of application, now available in *Super-Seal* open-type motors, are drastically changing motor application standards. These insulations are so completely impervious to moisture and contaminants that *Super-Seal* open motors can be used in most applications formerly requiring costly enclosed designs. Existing applications have resulted in savings as high as 60%.

### Basic insulation systems

Larger *Super-Seal* motors with form-wound stator coils use the *Silco-Flex* insulation system. Heart of this system is a remarkable rubber-like silicone elastomer, applied in semi-cured state and vulcanized to form a void-free, impervious dielectric barrier. More than four years of development and field testing have proven the superior electrical and physical properties of *Silco-Flex* insulation systems.

Stator coils of smaller random-wound motors are protected by equally effective *Poxeal* insulation system. A tough, durable case of epoxy resin completely seals the winding end turns and slot portions. Bonded to the stator laminations, it forms a seal completely impervious to contaminants.

### Moisture resistance

In addition to being void-free, the silicone elastomer used in *Silco-Flex* insulation is moisture repellent. Even in high humidity, moisture does not form a surface film of condensation. Coils with this protection can operate completely immersed in water. In fact, one of the recommended cleaning procedures is use of detergent and water.

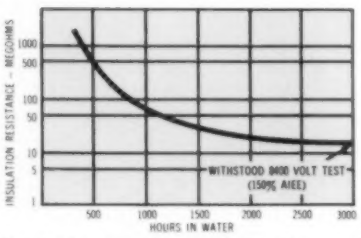



**Fig. 1**—Test curve shows insulation resistance of *Silco-Flex* insulation while immersed in water.

Moisture resistance of *Silco-Flex* coils is demonstrated in Fig. 1. After more than 3000 hours of total immersion with 2300 volts impressed on the coil, the test was terminated when it became apparent that little more drop could be expected in the coil's insulation resistance. At that point the coil still withstood a high potential test of 8400 volts without injury.

Encapsulated stator windings are equally well sealed. Motors with *Poxeal* insulation protection have been thoroughly tested under water while operating with full load and full voltage.

### Resistance to contaminants

Silicone elastomers and epoxy resins are relatively inert to attack by practically all reactive agents. Further, the void-free construction of insulation systems used in *Super-Seal* motors prevents penetration of contaminants. As a result, *Super-Seal* motors are unaffected by oils, most acids, salt solutions, alkalies, and oils and are ideally suited for such applications.

### Thermal stability

Temperature-wise, *Silco-Flex* insulation can easily withstand hot-spot temperatures of 200 C and more—

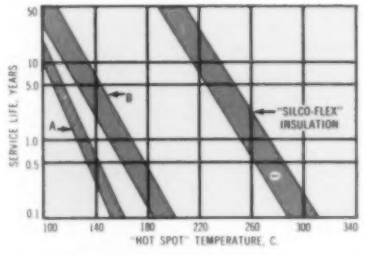



**Fig. 2**—Chart shows that *Silco-Flex* insulation more than meets Class H requirements.

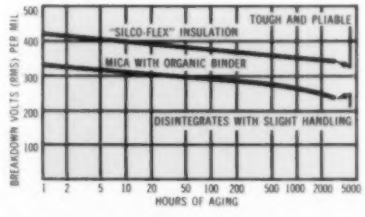
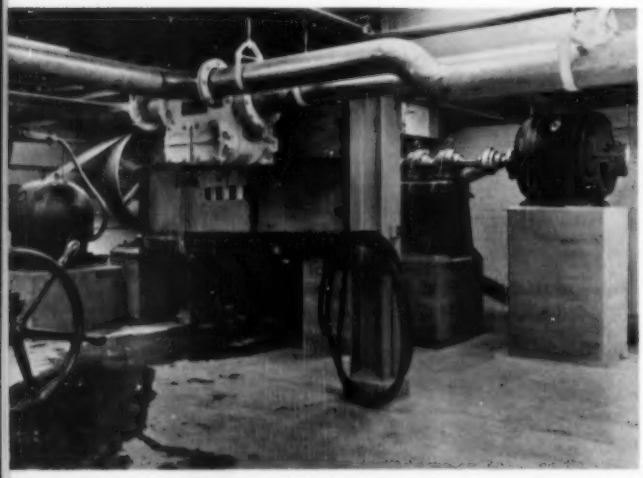



**Fig. 3**—Tests of 2300-volt insulated bars show thermal stability of *Silco-Flex* insulation.



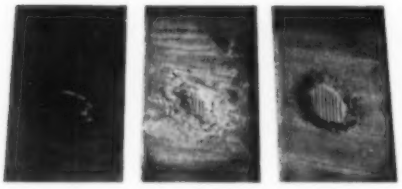
**Paper mills** have wide application for *Super-Seal* motors because of moist atmospheres.

easily meeting Class H temperature requirements (Fig. 2). At temperatures where the life of Class B coils would be measured in weeks, the life span of *Silco-Flex* coils is well beyond machine obsolescence.

Comparison with a mica-organic binder insulating system (Fig. 3) offers further proof of thermal stability. After 2000 hours of aging at 200 C with 8500 volts applied continuously, the *Silco-Flex* insulated coil was still tough, pliable, and completely serviceable. The mica-taped insulation had deteriorated to the point where it disintegrated readily and was completely useless.

An added advantage of *Silco-Flex* insulation is unusually high thermal conductivity — about twice that of conventional insulations. This means heat dissipates faster from its point of generation.

*Poxeal* insulation also demonstrates remarkably good thermal stability. Materials now in use are suitable for Class B temperatures, although actual classification of the insulation is determined by the basic material used.



*Silco-Flex* Insulation | Polyester Mica Tape | Asphaltum Mica Tape

**Fig. 4**—Samples of motor insulations after sandblasting give comparison of abrasion resistance.

### Abrasion resistance

Resistance to abrasion is still another point of superiority in the insulation systems used for *Super-Seal* motors. Abrasion resistance of *Silco-Flex* insulation is compared to other types of insulation in Fig. 4. After one minute of sandblasting with 90-grit aluminum oxide and 100-psi air, only slight surface erosion appeared on the *Silco-Flex* sample. Other insulations were eroded to bare copper.

### Application practices obsolete

The superior qualities of *Super-Seal* insulating systems, developed by Allis-Chalmers, make it necessary to reappraise present application practices. With virtually ageless insulation, *Super-Seal* motors assure more reliable service and require less upkeep than the best protected, conventionally insulated machines — and at considerably less cost.

*Super-Seal, Poxeal, and Silco-Flex are Allis-Chalmers trademarks.*


CHRYSLER KIMBERLY-CLARK GOODYEAR SOUTHERN CEMENT CONTINENTAL CAN AMERICAN OIL CELOTEX SCOTT PAPER HURON PORTLAND CEMENT FORD FIRESTONE PACIFIC GAS & ELECTRIC STANDARD OIL OF INDIANA B. F. GOODRICH DOW CHEMICAL MARLEY INGERSOLL-RAND LINK-BELT

# WIDE ACCEPTANCE

## of Super-Seal motors proves their advantages

Cement, petroleum, chemical, steel, mining, paper, utilities, municipalities and general industry — outstanding corporations in every field are specifying *Super-Seal* motors wherever operating conditions are tough.

*Cost* and *superior insulation* aren't the only reasons. Users are getting MORE MOTOR, too. Here's why:

Standard totally-enclosed motors, 55° C rise, have a *service factor of 1.* In other words, "nameplate" horsepower is the maximum. A 40° C rise *Super-Seal* motor with *Poxeal* insulation, and a 60° C rise *Super-Seal* motor with *Silco-Flex* insulation have a *service factor of 1.15.* For comparisons on what this difference means in required motor sizes, see this chart:

| Rated Horsepower (Maximum Hp, TEFC) | Maximum Continuous Hp—Super-Seal Motor |
|---|---|
| 15 hp | 17.25 hp |
| 25 | 28.75 |
| 40 | 46 |
| 75 | 86.25 |
| 125 | 143.75 |
| 200 | 230 |
| 350 | 402.5 |
| 500 | 575 |

**Join the swing** to *Super-Seal* motors. It will pay dividends fast. Contact your A-C representative or distributor, or write Allis-Chalmers at address shown on back page.

**ALLIS-CHALMERS**

SOUTHERN CALIFORNIA EDISON LONG ISLAND LIGHTING AVCO UNION BAG UNIVERSAL ATLAS UNION CARBIDE OHIO OIL INTERNATIONAL PAPER SOUTHERN PACIFIC PIPE LINE ALCOA ROHM & HAAS ARMOUR SHELL OIL COMMONWEALTH EDISON OWENS-ILLINOIS WYANDOTTE CHEMICAL BETHLEHEM STEEL ALLEGHENY-LUDLUM MEAD DU PONT DETROIT EDISON ESSO HERCULES POWDER SINCLAIR PIPE LINE GENERAL TIRE MONSANTO

# This *SUPER-SEAL* MOTOR application SAVED $3000!

## Find out how much you can save

This application of a *Super-Seal* open-type motor — in place of a weather-protected design of the same rating — *saved the user $3000.00!*

**You can achieve similar savings!** Fill out the data sheet below and *find out for yourself how much you can save — on a "no-strings-attached" basis.*

**Here's what to do:** 1) Select an enclosed motor application in your operations (a new motor need or, for comparison, a motor just purchased); 2) fill out the data sheet; 3) mail to the address shown.

**We'll give you a cost quotation** on a *Super-Seal* open motor for that application.

## Fill out this data sheet—

no strings attached—to find out how much you can save on a new motor or on an existing motor installation

To: **ALLIS-CHALMERS**
888 S. 70th St., Milwaukee 1, Wis.

### Motor Data

1. Type (i.e., squirrel cage):

Horizontal ☐ Vertical ☐

Hp ..... Rpm .....

2. Phase ..... Frequency .....

Voltage .....

3. (For synchronous only)

Power factor .....

Starting torque .....

Pull-in torque .....

Pull-out torque .....

### Application Data

4. Description of application:

5. Drive: Direct-connected ☐

V-Belt ☐ Other: .....

Starting load .....

Ambient temperature .....

6. Operating conditions: .....

Dirty ☐ Clean ☐ Wet ☐ Dry ☐

Other .....

### Information on Existing Motors
(for comparison)

7. Type of insulation .....

Type of enclosure .....

Time rating .....

Temperature rise .....

Bearings:

Anti-friction ☐ Sleeve ☐

8. Special characteristics or construction:

NAME .....

TITLE .....

COMPANY .....

ADDRESS .....

A-5869

**ALLIS-CHALMERS**

# DEVELOPMENTS TO WATCH...

## Titanium gears outlast steel . . .

. . . in lubricated wear tests and are able to take a "terrific beating," says Western Gear Corp. Tests of its phosphorous-nickel coated gears (*PE–May 12 '58, p 20*) in high-speed aircraft components, Western says, show they were able to perform seven 5-minute, full-load cycles at 196,000 (Hertz) compressive stress; had a PVT (pressure-velocity-temperature index) of 2,000,000, and bending stress of 47,000 psi. In lubrication tests with a Shell 4-ball tester, Western reports, the coated titanium gears showed a higher initial wear rate than 52100 steel, but a lower one after 15 min. in the machine.

## Guided buses will be roaming the streets of Chicago . . .

. . . if present plans of Chicago's Transit Authority pan out. CTA says it has already done "considerable research" on guided-bus trains, is working with such companies as Barrett Electronics Corp to develop the necessary guidance equipment. (Barrett produces several types of remote-control guidance systems for industrial trucks.) However, actual field testing will probably not start before spring.

## Fungi that live without air are becoming a Space-Age headache . . .

. . . Wright Air Development Command researchers report. Far from solving the problem of fungi and bacteria, space travel, and the desire to keep the moon and other satellites uncontaminated until they can be studied, simply compound the problems already posed by these tiny organisms. Tests at Wright Field have shown that some fungi and bacteria can survive more than a month at pressures as low as $5 \times 10^{-7}$ mm Hg–about what would be encountered 100 miles out.

## Infinitely variable speed and ease of conversion . . .

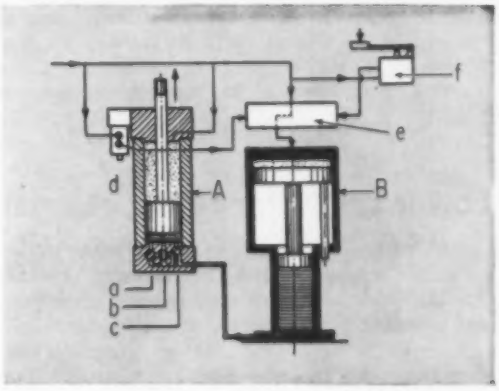
. . . to automatic control are two advantages claimed by Specken AG, Zurich, Switzerland, for the hydropneumatic machine-tool system diagrammed here.

By using compressed air as the primary power source, and a secondary hydraulic system to increase the pressure, Specken says it is possible to produce "an infinite variety of speed-stroke characteristics for the feed of any tool carriage, and convert almost any manually controlled machine tool into an automatic one."

The system consists of two major units: an operating cylinder *A* and a pressure converter *B*.

The operating cylinder is so designed that a control rod moving with the piston actuates valves *a*, *b*, *c* and *d* which, in turn, control its travel in both directions. The piston itself may be connected directly to the tool carriage; or, by means of a rack mechanism, to the feed pinion of the machine.

The pressure converter is, essentially, a dual piston; one surface being larger than the other. Air is fed in above the larger one (at the top) and oil is contained beneath the smaller one (at the bottom). Size is chosen so oil pressure will be approximately




4 times the air pressure. By controlling the initial air pressure (with valve systems e and f), the company says, it is possible to provide for automatic stopping at either end of the stroke or in between, automatic reversal, high-speed return, and retarded reversal. It is also possible to interconnect several tool carriage drives for successive or phased operation.

# DEVELOPMENTS

## TO WATCH...

## Stable lubricants can be developed for high-temperature use . . .

. . . says Naval Research Lab, by taking advantage of new fluorocarbon systems.

Noting that the alkyl diesters covered by military specifications MIL-L-7808 do not have the oxidation and pyrolysis resistance required by aircraft gas turbines soon to become operational, and that fluorocarbon fluids previously tested were too volatile, the Chemistry Div of NRL has begun an investigation of a new group of fluoroesters.

Results thus far are encouraging. One compound, for instance, shows oxidation stability at least to 527 F and thermal stability to 600 F. NRL admits that "these gains are made at some expense of viscometric properties and freezing point," but its researchers are optimistic, saying, "the results of this investigation open the way to more stable and less volatile fluoroesters which offer promising candidates for high-temperature jet-engine lubricants." Research on the project (NA350-063) is continuing.

(Note: for information on other approaches to the problem of high-temperature lubrication, see PE–Dec 9 '57, p 9; May 5 '58, p 5.)

## Ultrasonic energy can be "piped" around corners . . .

. . . and transmitted to locations considerably removed from its source, says Sheffield Corp. The company is taking advantage of that fact in designing new tooling for its ultrasonic cutting machines, and believes the practical demonstration can aid design of other types of equipment.

Until now, Sheffield's Cavitron machines have been designed to transmit energy to a single machining station located directly beneath the transducer and at a distance of not more than 12 in. from it. Now Sheffield engineers say, "the new extension-type tooling transmits high-frequency mechanical oscillations from the transducer . . . to remote machining stations."

Sheffield's transmission system is a simple one: just curved, cylindrical rods leading from the transducer to the various work locations. As many as 8 machining stations have been mounted on a standard machine, with a transmission rod to each one, simultaneous or sequential operation.

## Better materials for thermoelectric power generation . . .

. . . are on the way, Air Force researchers believe, and they've already made considerable progress.

Right now, they term bismuth telluride one of the best, if not the best, material available for conversion of thermal to electrical energy. But, they note, it has a relatively low melting point–about 1090 F.

Researchers at the AF Cambridge Research Center have by no means abandoned bismuth telluride for this reason. As a matter of fact, they're setting records for production of single-crystal boules. But they're also testing other semiconductors, with every expectation of finding one that has bismuth telluride's advantages without its limitation.

## Lower prices for resins, refrigerants, fibers and finishes . . .

. . . are predicted as capacity to produce many organic chemicals outruns even today's booming demand. Already, price reductions are beginning to appear, and projected increases are being postponed.

Late last month, producers of isocyanates (for urethane foams and adhesives) lopped nearly 30% off quantity prices. Smaller, but still substantial cuts were made in polyvinyl chloride and polyvinyl acetate tags.

Producers of polyethylene–both standard and linear–and of fluorocarbons (for refrigerants, aerosols and molding resins), faced by capacities nearly double current demand, were out beating the bushes for new applications.

A. Jonnard of Shell Chemical summed up the current situation for many of the newer materials when, speaking of epoxy resins, he told the Chemical Market Research Assn: "Starting from the end-use pattern and the price structure of a few months ago, we came to the conclusion that real growth during the next few years could only be expected if the products were more attractively priced. Our economic data indicated that lowering the price might expand consumption sufficiently to more than compensate for the lower profit per unit of sales. Our new price schedule went into effect a few months ago. We hope that future growth will demonstrate that we used good judgment." –ARG

# Exclusive from Russia!—Design Details of the Lunik

BONN—Soviet scientists planned to hit the moon somewhere near its equator with the 104.9-ft Lunik they launched Jan. 2. That the artificial planet was not expected to orbit the sun is becoming increasingly clear from documental information now available in the Soviet Union.

Unexpectedly strong magnetic fields, encountered just prior to the third-stage cutoff, prevented the missile from hitting target. Still, Lunik's control system guided it to within 3° of target—a noteworthy feat. The Soviets attribute much of this success to apparatus that cut off burning in the missile's third stage with 0.1-sec accuracy after Lunik accelerated to escape velocity of 6.98 mi/sec.

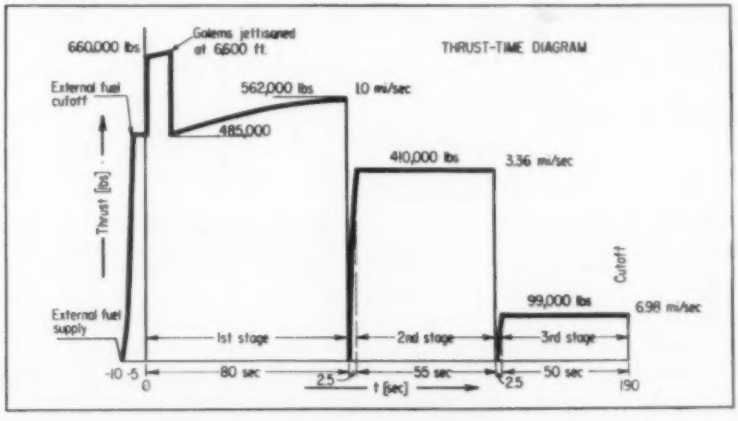
The three-stage, 352,000-lb vehicle, called the CH-10 by the Soviets, was similar in design to rockets that launched all three Sputniks. First stage was a modified T-3A ICBM; second stage, a modified T-2 IRBM; third stage, a specially designed vehicle for space flight.

In contrast with Sputniks, first-stage thrust for Lunik was supplemented by two solid fuel Golem 3's—rockets employed militarily as underwater-to-air or surface-to-air missiles. An exotic hydrocarbon fuel with boron additives was mixed with liquid oxygen in ratio of 2.4:1 in all three stages. The propulsion system produced initial thrust of 660,000 lb.

Nonessential equipment was rigorously excluded from Lunik. The missile carried no equipment to destroy it in flight. It did carry instruments for measuring magnetic fields, cosmic radiation, radioactivity, interplanetary matter, corpuscular radiation, micrometeorites and temperatures—along with 5 transmitters—four active and one stand-by—for sending information to earth. For the first time, electronic equipment in the rocket was fully transistorized and fitted to two-dimension printed circuits. According to Soviets much of the high purity germanium required came from Red China.

The missile also carried no vector rockets or solar-energy cells—partial evidence that it was expected to go only to the moon. Such equipment would have allowed radio transmission during solar orbit. Chemical batteries exhausted themselves in 62 hr, but permitted continuous communication when the vehicle passed through the earth's shadow. First independent check on distance covered by CH-10 was made when a preset timer released a 5-gram sodium cloud.

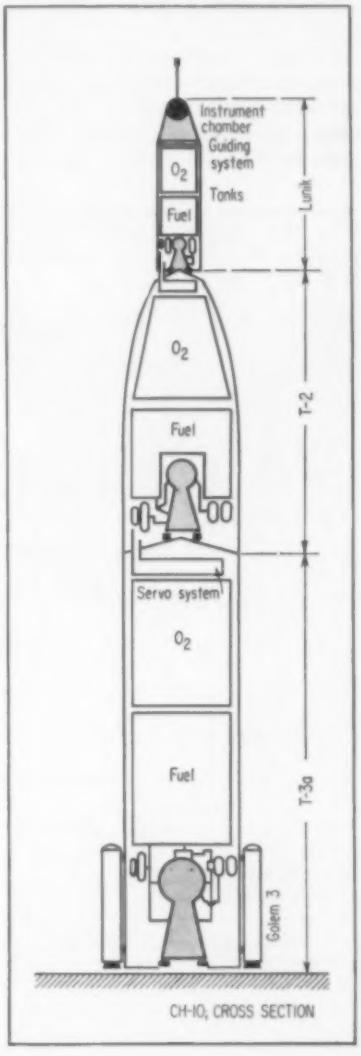
**At −5 sec in countdown . . .**
external fuel feed to rocket was cut off and first stage tanks cut in automatically. By zero time the missile had built up 660,000-lb thrust (485,000-lb from engines and 88,000-lb from each supplementary Golem) for initial push on trip to space. Golems were jettisoned at 6600 ft. At that point, thrust dropped to 485,000-lb output of rocket engine at takeoff, but by cutoff the engine had built up to 562,000-lb thrust. Between second and third stages, rocket coasted 2½ sec before severing to give engines time to build up full thrust.




First stage of the rocket weighed 184,800 lb including 167,200 lb fuel; second stage, 113,300 lb including 94,600 lb fuel; third stage, 24,150 lb including 20,900 lb fuel.

Outer skin of the airframe was constructed of chrome-plated steel rolled

**Russia's 104.9-ft Missile**
that bore Lunik aloft was composed of a 53.1-ft long first stage, 31.4-ft second stage and 20.3-ft third stage. First stage was 13.7 ft dia throughout, second stage tapered from 13.7 ft at base to 5.3 ft at top, third stage tapered from 5.3-ft dia. Instrument package, at top of final stage, weighed 797-lb and was 24.5-in dia.



against an aluminum alloy backing and stretched over a framework of aluminum and aluminum-magnesium alloy. Ribs and sheet were riveted together. Transition sections between stages were made of heat-resistant chrome-molybdenum steel. In place of using black and white stripes for controlling internal temperatures as the US did on Pioneer III, the Soviets painted their latest missile half black and half white.

Burnout of engines in each of the first two stages triggered ignition of the engine in the succeeding stage, but in both cases actual separation was delayed 2½ sec until new engines built up full power. Explosive bolts then separated missile sections. No retro-rockets were included in the design because thrust of incoming engines—located on nose cap of the preceding stage—was sufficient to make the break.

Thrust in both second and third stage was sufficient to spin the vehicle up to 60 rpm through its graphite rudders for stabilizing the craft. This contrasts with US moon-probe practice which uses up to eight vernier rockets for spin.

#### LAUNCHING AND TRACKING

The rocket was launched from an installation slightly north-east of the Aral Sea on the border of European Russia—latitude 47° N and longitude 62° 30′ E. Angle of injection was 71 deg from vertical.

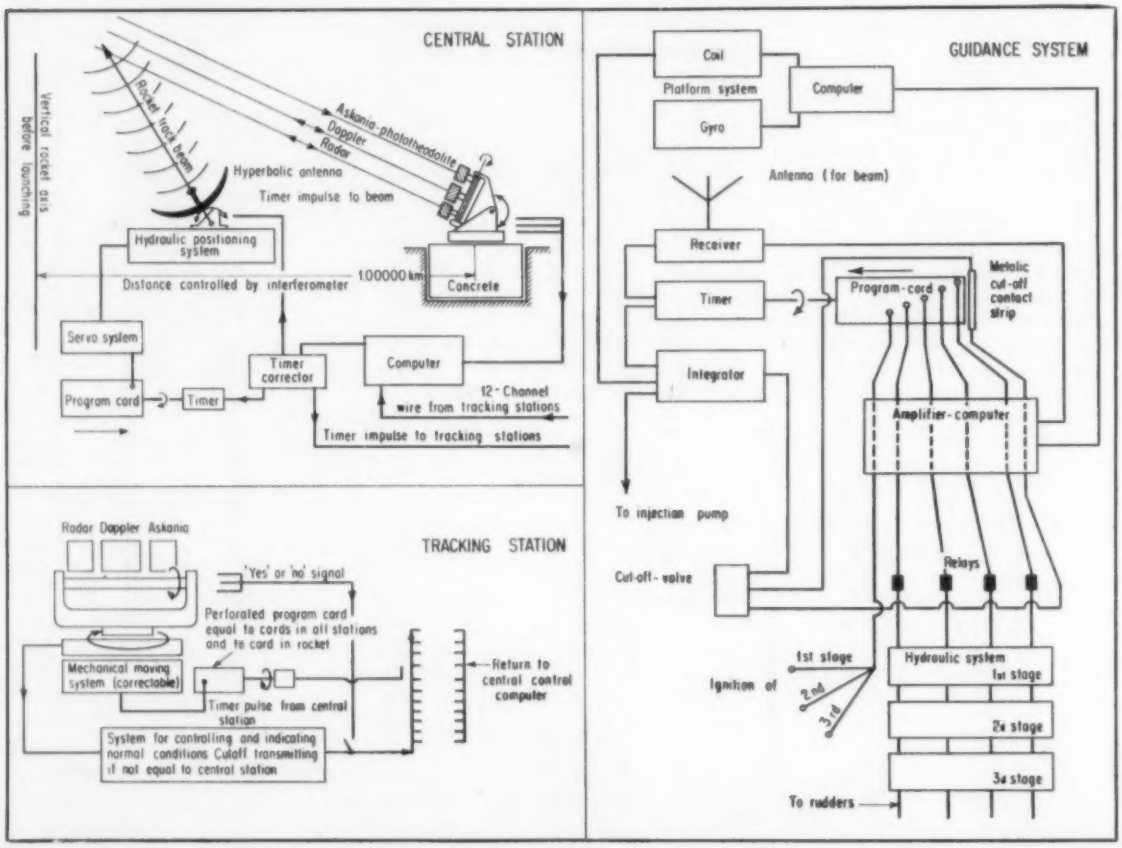
The launch pad was located exactly 3,280.84 ft from control headquarters. An interferometer checked this distance to five decimal places to ensure accurate relationships between vertical axis of the rocket and vertical axis of the Doppler tracker at main control station.

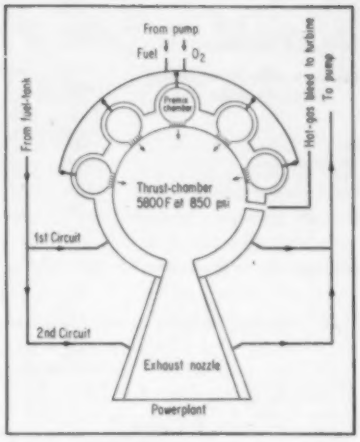
The missile was tracked by instruments at 13 stations stretched from Czechoslovakia to the Pacific. Each tracking station was equipped with Doppler, radar and phototheodolite equipment. Data from these three sources was aggregated in a computer and the results fed to an IBM-type machine.

The Doppler at tracking stations was conventional, and the 9.8-ft-dia radar operated on 12-cm wavelength. Theodolite equipment, based on the Askania principle, included parts that reportedly were manufactured in West Germany.

Guidance equipment was located in the third stage of the missile and at the main control center and tracking stations on the ground. The rocket can best be described as "time guided." That is, an ideal flight programmed on a perforated aluminum card was carried in the missile. Each succeeding step that was called for in this program was set off by crystal timer.

Simultaneously, ground installations checked the timing on the missile against duplicate iridium program cards. Reports from tracking station computers were passed to a master computer at the main control station. If the master computer showed a flaw in timing sequence on the space vehicle, a ground-based antenna beamed corrective instructions to control equipment in the vehicle. Corrections were made by synchronizing an electronic timer in the rocket with an






**Fuel from pre-mix . . .**
**chambers flowed to thrust chamber, thence to exhaust nozzle where its was cracked. But before fuel was passed out of exhaust nozzle, it was recombined to chemical form it had in thrust chamber. Gas bled from thrust chamber was fed to an expansion chamber for generating steam at sufficient pressure to drive turbines that operate fuel pumps.**

identical timer on earth.

The Soviets trace the efficiency of their guidance system to a combination of gyroscopes and induction coils in the missile that kept all three of its axes at correct tagent to a pre-set path and to the beam from earth that kept the rocket's center of gravity on its prescribed path. In the missile, three liquid-damped gyroscopes on stabilizing platforms in each stage controlled roll, pitch and yaw. A gyro system compensated for gravitational pulls on the vehicle, and two induction coils corrected the magnetic influences that cause roll and pitch. A third induction coil coupled directly with an integrator kept close control on acceleration of the vehicle by governing pressure of fuel injected into the thrust chamber.

Pulses generated by these gyroscopes and induction coils were transferred to a computer, an amplifier, and then to a second computer containing the missile's control program. These pulses were finally transmitted over relays to hydromechanical apparatus that changed position of four sodium graphite rudders at rocket nozzle.

Corrective impulses beamed from the ground to the missile were picked up by the rocket's receivers and transmitted to an integrator by the timer. After the correcting pulses were integrated, the results were relayed to the amplifier-computer and then to the hydromechanical system that controlled the rudders. Similar to the predecessor Sputniks, the Russians chose graphite rudders tied to the thrust system in preference to the weighty and more cumbersome gimbal-hung engine preferred by the US.

Tungsten-carbide-lined thrust chambers in all three stages were designed for Russian-type exotic fuels. Duplicating Sputniks, the thrust chambers of Lunik were surrounded by a series of pre-mix chambers to insure perfect fuel blend. These chambers make higher thrust chamber pressure possible and resulted in exhaust velocities of 9348 to 10,000 fps, the Soviets say.

To mix the fuel, individual injectors forced hydrocarbons and liquid oxygen into the pre-mix chambers at pressures varying from 1918 and 2556 psi, depending on thrust needed at the nozzle for pre-set velocity. Steam turbines drove fuel pumps in all three stages. In the thrust chamber, 5800-F temperature cracked the fuel—$CO_2$ and $H_2O$—to $2CO + O_2$ and $2H_2O_2$ and then recombined it to the original $CO_2$ and $H_2O$. This sequence reduced specific fuel consumption of Lunik's propulsion units to 9.2 lb/ton/sec compared with 10 to 10.5 lb/ton/sec reported for Viking engines.

To protect missile structures against the searing heat, rocket fuel was pumped through the jackets, around the thrust chamber and nozzle to hold wall temperatures to 1112F.

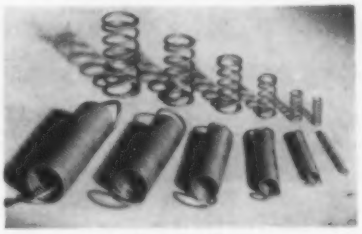
Information indicates that the study of reentry problems has progressed to a point where the Soviets now can bring a vehicle of modified Lunik configuration back to earth. While US scientists have worked with radiating surfaces to dispose of heat input during reentry, the Soviets have experimented with water jacket cooling (now believed discarded because of its weight) and simple wooden jackets. In the latter, the nosecone is enclosed in a wooden jacket dimensioned so it will smolder and burn away during the relatively short reentry period. The nosecone of the satellite is left reasonably cool.

## R & D Costs Climb Twice as Fast in 3 Years as Hiring Rate of Scientists, Engineers

WASHINGTON—By January, 1957 there were 528,000 engineers and 152,000 scientists in the US. Only one-third of these were engaged in R & D activities. So reports the National Science Foundation in its Scientific Manpower Bulletin #10 compiled by the US Bureau of Labor Statistics.

Engineers and chemists comprised the largest occupational groups among the 228,000 scientists and engineers in industry in R & D. However, rate of employment in R & D varied, ie, 3 out of 5 physicists compared to less than 1 out of 3 engineers, mathematicians, or life scientists were in R & D work. Some 160,000 of the 600,000 technicians, working with scientists and engineers, were engaged in R & D.

From 1954 to 1957, US industry, according to the report, increased its employment of scientists and engineers by about 30%. Number of engineers rose by 27%, chemists by 16%, life scientists and physicists by about 60%. In R & D, such employment increased by more than 45%—only slightly more than half the 80% increase in R & D costs reflected during the 3-4 year period.



**Springs—off the shelf . . .**
**will be available shortly for the range of sizes and shapes of tension and ground end compression springs commonly used—1 to 20 lb load, OD from 1/8 to 3/4 in and lengths to 1 1/2 in. for compression and 5 in. for tension. Wallace Barnes, Bristol, Conn, has designed approximately 500 standard springs in progressive increments of size and load that fill about 90% of the specific requirements met in service. Diameters are correlated with commonly used drilled-hole sizes. Each size will be available in both music wire and stainless —certified to military and aircraft requirements. These standard sizes eliminate the need for designing a spring or making a drawing; each size will be identified by a catalog number. Springs will be carried in stock for faster delivery and lower cost in small quantities needed for short run or development work.**

# See More R & D Defense Dollars Added to US Budget

WASHINGTON—There seems no question but what Congress will increase the present $77-billion balanced budget; that there will be more money spent on defense (R & D will get much of this increase) is not being debated. But the big issue is by how much. One thing seems sure, the budget is destined to become a political football. And, many think it was designed for just that purpose.

The Administration is holding tight to its theme that the budget represents a sound appraisal of national needs for the coming year. The Democrats are blasting it as being pared beyond the point of good judgment.

Singled out for a good share of Democratic criticism is defense spending. The Administration is asking for $40.9 billion—only a $145-million increase over last year.

Critics point out that this does not even allow for the normal 3% inflationary cost increase that Pentagon budget experts admit has been creeping into military prices regularly over the past years.

#### WHERE IKE IS CUTTING

To justify its defense budget, the Administration says that successful development of many of the nation's missiles, as well as changes in tactical concepts has eliminated the need for others, and they are being dropped. The solid-fueled Pershing and Sergeant missiles, for example, will replace the liquid-fueled Redstone and Corporal; Navy's fast-moving Polaris program makes it possible to cut the Regulus II missile; the air-to-ground Rascal missile has been cancelled; the Decoy missile goose has been cancelled; and the Navy's jet Seamaster project will be stopped

While manned aircraft is being cut, the Administration has increased missile production money by $500 million. But, the Democrats claim it is not enough. And they want to make a sweeping investigation into the whole defense posture of the nation. Even the most conservative critics admit that it is sure to swell the defense portion of the budget before the matter is settled. It is the same type of investigation that caused Congress to increase the military budget last year by some $900 million.

It is not only the military section of the budget that the Democratic Congress will attempt to fatten. Last year, it was the Russian Sputnik, and US satellite shoot failures that spurred Congress into a budget increasing mood. This year, the attention is more on domestic vote-getting issues.

# UK Shows Largest Plastic Yacht

LONDON—What is claimed to be the world's largest fiberglass-laminated boat is being shown at the annual British Boat Show at Olympia, London. The craft is 56 ft long, has a displacement of only 16 tons and will travel at 17 knots. Propulsion is by twin screws, each driven by a 150-hp Mercedes-Benz diesel engine.

Manufacturers of the hull, Halmatic Ltd, Fratton, Portsmouth, claim a wooden vessel of same length would displace nearly 20 tons and, with the same engine, would do little better than 13 knots.

Weight of the fiberglass hull is 5000 lb and compares in cost with a wooden structure—about $11,000.

The cold, hand-laminating techniques used are the same as those for smaller plastic boats. Frames and widely spaced stringers, integrally molded with skin panels, are also the same. Frames are three in. wide, pitched at 15-in. centers. Object of the frames is to increase stiffness for minimum skin thickness, fiberglass laminate being stronger than wood, but not as stiff. Frames and panels run continuously round the vessel, without longitudinal joints.

Designers claim a wooden hull of same length would take nearly 560 lb paint and absorb about 10% of its own weight in water—with both factors increasing the drag.

Switching to plastics has also increased flexibility in contour selection and appearance. Bow flare is exaggerated, spray-deflection is built-in, and the stem above water-line is rounded.

**1960 R & D Budget**

**Research and Development Major Agencies**

| | 1959 | 1960 (millions est.) |
|---|---|---|
| Dept. of Defense | 3,282 | 3,692 |
| Atomic Energy Commission | 618 | 652 |
| Nat'l Aeronaut & Space Adm | 205 | 333 |
| Health, Education & Welf | 236 | 251 |
| Total, All Agencies | 4,841 | 5,484 |

**Dept. of Defense—R&D, Test, and Evaluation**

| | 1959 | 1960 (millions est.) |
|---|---|---|
| Military Sciences | 360.3 | 371.9 |
| Aircraft, Related Equip | 472.6 | 487.3 |
| Missiles, Related Equip | 1,341.8 | 1,437.6 |
| Military Astronautics & Related Equip | 345.9 | 309.1 |
| Ships and Small Craft & Related Equip | 158.7 | 167.7 |
| Ordnance, Combat Vehicles and Related Equip | 188.8 | 235.0 |
| Other Equip | 379.9 | 430.8 |
| Program Mgmt. and Support | 137.8 | 133.0 |
| Emerg. Fund, Expired Accts | 136.1 | 150.0 |
| Total | 3,521 | 3,722 |

**National Aeronautics and Space Admin. Research and Development Programs**

| | 1959 | 1960 (millions est.) |
|---|---|---|
| Aircraft, Missile, Spacecraft Research (Support of NASA Plant, JPL Plant, and Research Contracts) | 13.9 | 33.0 |
| Scientific Investigations in Space (Sounding Rockets, Earth Satellites, Lunar Probes, Deep Space Probes, Vanguard Program) | 110.5 | 118.3 |
| Satellite Applications Investigations (Meteorology, Communications) | 8.1 | 28.0 |
| Space Operations Technol. (Manned Space Flight, Rendezvous Techniques)* | 37.66 | 73.0 |
| Space Propulsion Technol. (Solid Fuel Rockets, High-Energy Fuel Rockets, 1-mil. Pound Single-chamber engine, Nuclear Rocket Engines, Space Engines, Auxiliary Power Units) | 29.0 | 64.0 |
| Space Systems Technology (Advanced Vehicle Systems, Booster Recovery Systems, Orbiting Space Lab) | 1.0 | 5.0 |
| Supporting Activities (Tracking, Data Acquisition) | 4.3 | 11.5 |
| Total | 204.6 | 333.0 |

*—Supplemental Est FY '59—20.750

| Education | 1959 | 1960 (millions est.) |
|---|---|---|
| Nat'l Science Foundation | 66 | 66.6 |
| Health, Education & Welf | 115.3 | 150.0 |

(Includes 75.3-mil. in Supplement 1959 Request)

| | | |
|---|---|---|
| Air Pollution | 4.0 | 4.2 |
| Saline Water | 1.2 | 1.3 |
| Nat'l Bureau of Standards | 12.3 | 17.5 |

(Research & Tech. Serv).

# Pentagon Names York to Unsnarl Defense R & D

WASHINGTON—The Pentagon's wide-ranging research and development bureauracy is undergoing a major overhaul. Though the situation is still in flux—with decisions on organizational detail and administrative procedure still to be ironed out—it's now clear that one man, Dr. Herbert F. York, the Defense Dept's new Director of Research and Engineering, will have more direct power over military R & D than any one man has ever had before in the Pentagon.

York has authority to "supervise" all military R & D work and to "direct and control" those projects which the Secy of Defense determines should be under "centralized management." As the Defense Secy's "principal adviser on scientific and technical matters," York will presumably have a lot to say what projects these will be.

He is an old hand in military R & D. For the past year, he has been chief scientist for the Defense Dept's Advanced Research Projects Agency, (ARPA) which directs military space projects. He is a noted physicist, played a prominent role in the atom bomb project during World War II, and was associate director of the University of California's famed radiation laboratory before coming to the Pentagon last year.

He has a reputation at the Pentagon as both a vigorous and imaginative administrator and as a brilliant scientist familiar with the nuts and bolts of major R & D projects. Indications are that York will bolster military R & D management—which in recent years has become entangled in bureaucratic disputes over fund allocation, project assignment, and administrative authority.

York's new post was established in Congress last year in the Defense Dept Reorganization Act. His appointment came after McElroy tried unsuccessfully for months to lure someone from industry to take the job.

The new director will have power to allocate funds from the Defense Dept's R & D emergency fund ($150 million voted last year and another $150 million sought this year); to have direct authority on how the Army, Navy, and Air Force spend the billions in R & D funds appropriated directly to the individual services; to approve contractor selections; to initiate projects; and to assign them to the services. Presumably his authority will run the gamut of all military R & D—electronics, missiles, aircraft, eventually space, and the like.

The position of William M. Holaday, the missiles "czar" who never really became a "czar," is being abolished. Holaday was named Defense Dept Director of Guided Missiles during the Pentagon's recent drive to speed up missile work and to clarify lines of authority. His 38-man staff will be absorbed by York's new shop.

The position of ARPA, the one-year old agency which directs military space projects, is very much up in the air. Theoretically, ARPA activities fall under York's new office. But ARPA director Roy W. Johnson, a former GE Vice-president and York's former Pentagon boss, continues to report to McElroy directly rather than to York.

However, expect ARPA to wither on the vine and eventually become incorporated in York's office. Under present plans, York plans to farm out actual administration of most R & D projects to the services and their contractors. But York will also be able to award contracts himself.

## Separate Professional Employees from Others

WASHINGTON—The right of professional employees to a separate vote in elections conducted by the National Labor Relations Board to determine questions of representation under the Taft-Hartley Act has been sustained by the Supreme Court, it has been reported here.

The case involved professional employees at the Westinghouse Buffalo plant, who, in the name of the Westinghouse Engineers' Assoc, EAS, petitioned to represent 233 professional employees. But the NLRB tacked onto the petition the names of 9 admittedly non-professional employees. WEA took the board to court claiming such inclusion of non-professionals during an election flouted implicit provisions of the T-H Act.

# COMING EVENTS

**February**

**3-5** . . . Society of the Plastics Industry, 14th Annual Technical and Management Conference, Edgewater Beach Hotel, Chicago.

**6-7** . . . University of California, 11th Annual Industrial Engineering Institute, Berkeley and Los Angeles Campuses.

**23-26** . . . American Society of Mechanical Engineers, Symposium on Thermophysical Properties, Purdue Univ, Lafayette, Ind.

**25-26** . . . US Atomic Energy Commission and Kansas State College, Midwest Industrial Radioisotopes Conference, Kansas State College, Manhattan, Kansas.

**March**

**3-5** . . . Institute of Radio Engineers, American Institute of Electrical Engineers, Association for Computing Machinery,

1959 Western Joint Computer Conference, Fairmont Hotel, San Francisco.

**8-11** . . . American Society of Mechanical Engineers, Gas Turbine Div, Engineering Conference and Exhibit, Netherlands-Hilton, Cincinnati, Ohio.

**9-12** . . . American Society of Mechanical Engineers, Aviation Conference, Statler-Hilton, Los Angeles.

**16-18** . . . Society of Automotive Engineers, National Passenger Car, Body and Materials Meeting, The Sheraton-Cadillac, Detroit, Mich.

**31-2** . . . 21st Annual American Power Conference, Hotel Sherman, Chicago.

# Chinese Issue Export Catalog

PEKING—The China National Import Corp is circulating an English language export catalog describing a line of machine tools and allied equipment. Though the brochure is probably prestige effort rather than a bid for actual sales, it is written in impeccable English, and possibly foreshadows trade ambitions with the West.

The five sections of the catalog cover machine tools; electric motors and control gear; internal combustion engines; pumps, compressors and pneu-

matic tools; small tools and miscellaneous items including crushing machinery, handling equipment and woodworking machines.

In the machine tool section, the brochure lists 23 lathes, 18 grinders, 11 milling machines, 13 drilling machines, 5 gearcutting machines, 4 boring and milling machines, 9 presses and shearing machines and a series of guillotine machines. The lathes range in variety from a 146 by 550 mm bench lathe to a 10-ft Ming Ching Model F machine. The latter possesses geared head, motor drive, quick change gearbox, vee bed, hollow spindle, and 260 mm center height with 1830 mm between centers. Spindle bore is 54 mm. There are 12 spindle speeds from 12 to 512 rpm driven by a 4.5 kw motor. The catalog gives no prices or delivery information.

## Machine Translating Chinese

VIENNA—The Soviets hope to solve the problem to translate the intricate Chinese characters into the Cyrillic alphabet using a machine similar, but more complicated than the functioning English-Russian machine.

Moscow just announced that work on the general problem of automatic translation began in 1955, and was conducted at the Institute of Precise Techniques and Computation Mechanics and the Institute of Scientific Information of the Academy of Sciences. The work done thus far has been mostly in English-Russian translation. The machine consists of about 5,000 Russian and English words, making it possible to translate long sentences and whole pages.

Work has now begun on automatic translation from Chinese into Russian, and the Soviets claim satisfactory results have been obtained.

### GM Gas Turbine in Engineering Development Stage

DETROIT—The gas turbine engine demonstrated in General Motors' Firebird III is being tested in a Cadillac-built M-56 lightweight military tank according to GM Research Laboratories' Engineering Development Dept, indicating a competitive future for the GT-305 in the heavy duty commercial, military vehicle field.

# READER TO EDITOR

### Protect US Patents Abroad

*To the Editor:*

I understand that there has been discussion recently to modernize international treaties relating to patents. In view of the fact that large amounts are being paid by the USA in royalties to foreign countries and smaller amounts are being received from them, it seems timely to protect US interests a lot better than we do now.

Now that Europe has recovered with US help, it does not have to be spoonfed any more, and the rights of US inventors should be more on par with the rights which the foreign inventor enjoys here. More reciprocity seems in order. It appears reasonable to reciprocate in "working requirements," period of patent protection, and not to forget the yearly taxes imposed on US patentees.

These changes would go a long way in the direction of abolishing these nuisances abroad, because a simple calculation would show to many countries this would be economical to them too. The Patent Office surely can use the money. Administration of fee collection would be simple because failure to pay up would invalidate the rights of a foreign patent-holder here.

—FREDERICK NETTEL
*New York City*

### Handwriting Analysis Rebuked

*To the Editor:*

Sorry to spoil the fun related to the recent exchange on handwriting analysis, but this might restore some confidence in personnel people. The Prudential Insurance Co made a study to see if graphology is valid in predicting the performance of salesmen. Dr. Ulrich Sonnemann's results in this investigation could produce no predictive conclusion.

You can see that research methods can and are used by the social sciences, as well as the physical sciences. Although many agree that scientific tools should be tried more extensively, patience is needed.

—W H GRAHAM
*Kaiser Aluminum & Chemical Sales Inc*

### Don't Name Product After Inventor

*To the Editor:*

In your Dec 22 issue of PRODUCT ENGINEERING, p 28, appeared a letter, "Name the Product after the Inventor." Might I ask why the writer does not agree with the present method used by commercial companies?

1. Who appropriates the capital for the design and development of a project?
2. Who then, should have the voice as to whose name is listed as the inventor or whether his name is made public?
3. Any inventor that I am acquainted with receives his glory and satisfaction from having accomplished the "impossible."
4. Any inventor that I know would rather receive the official recognition through his salary check.
5. Dalton's Law, Diesel engine, etc are all right for these easy to spell and pronounce names.

Let us not advocate a "new look"—for Czarnikow Sputnik would not be so easy to master. For that matter neither would Oettinger Germanium Generator.

—CARL L. WEBBER
*General Photronic Co*
*Plymouth, Fla*

### Slide Rule Wax

*To the Editor:*

On page 38 of you Dec 1 issue I read about A. E. Newton and his trouble with slide rules. It appears to me that the sliding parts of his slide rule need adjusting or a touch of wax. I have used the eraser end of a pencil for some years by pressing it against the stationary part and rolling against the crosshair at the straight surface. The action at the spring end would tend to slant the crosshair. I have been using my slide rules since sometime in 1930.

—GEORGE H. FROST
*Haverhill, Mass.*

### Upholsterers Hammer

*To the Editor:*

In the Reader-to-Editor column Dec 22 p 28, a letter from W. Richard Marsh of Edinburgh illustrated a special hammer used by upholsterers in Birmingham, England. This reader is surprised that the standard upholsterer's hammer is available in most good hardware stores was unknown to you.

—J. C. BERNEY
*Costa Mesa, Calif*

*To the Editor:*

I was interested to see the letter from Mr. Marsh of Edinburgh on this subject. This method of drivng tacks has been used by upholsterers (we call them trimmers) in this country for many years and it is popularly supposed that experienced workers are able to knock off for lunch with a mouth full of tacks, eat their lunch and go back to work again immediately afterwards using the tacks that have remained in their mouth all the time.

There are occasionally accidents in which tacks are swallowed and the writer's experience twenty years' ago in a large body plant, established the fact that it was cheaper to put in our own X-Ray plant to examine suspects rather than to pay transport and examination fees at the local hospital.

The remedy for swallowed tacks was simple and infallible. The victim was given a sandwich of cotton wool in bread and butter to eat. This wrapped itself round the tacks making them harmless and a further X-Ray in twenty-four hours or so soon showed that nature had done her work and no ill effect was suffered.

—A. H. VAN HOOYDONK,
*Managing Director*
*Exactor Ltd*
*Edgware, England*

LESSON V . . .

# FIVE STEPS TO FASTER READING

By THE READING LABORATORY INC

In the past four of these six articles, you have learned techniques for improving both reading speed and comprehension: Read phrases rather than single words; pre-read, skip and skim; keep your purpose in mind while you read; ask questions and anticipate in order to become involved with your reading; adjust reading rate and method to the difficulty of the material.

A good vocabulary is also essential, and an efficient reader works constantly to improve it further. He is a "critical" reader, not satisfied with understanding alone, but ready to evaluate statements and ideas. Finally, the efficient reader is able to summarize, retaining a pattern of major ideas rather than a collection of isolated facts.

**You cannot become a skilled reader without a well-rounded vocabulary.** If you come across an unfamiliar word while reading, try to determine the meaning through the context of the sentence and put a light check mark in the margin. Then, when you have finished reading the article, look up the definition in the dictionary. Try to use the word yourself, in your everyday speech. If you are investigating a new field, where you may be coming across the same words again and again, keep a list with definitions and the context in which you first encountered each word. This practice will help you to develop and retain a better reading vocabulary.

The vocabulary situation is, in a sense, a vicious circle. For the more you read and acquire new words, the easier reading will become for you. You will be able to recognize phrases more quickly and accurately. The faster and easier the reading process, the more you will read. And so the process goes.

**Adjust pace to the purpose.** An automobile has several gears for several purposes: low for power–hill climbing, driving on slippery ground and rough places; high for ordinary roads; overdrive for speed–deserted roads and superhighways. You can adjust your reading gear in the same way, according to your purpose in reading and the difficulty of the material. After pre-reading, determine which reading rate to use.

LOW GEAR (painstaking, thorough reading): Important and difficult new concepts in your field. Reading in another field for material which you need, the terminology of which is strange to you.

HIGH GEAR (normally fast reading): Fairly routine articles in your own field. Nontechnical but important topical material. Departments in PRODUCT ENGINEERING (slowing into low when an item is particularly important to you).

OVERDRIVE (skipping, skimming): Reviewing material already familiar to you. Searching for a particular fact in otherwise irrelevant material. Fast glimpse of main ideas in an article that is reasonably easy for you.

Turn to the Table of Contents on page 3 and decide which "reading gear" you would use with each article. Practice changing gears.

**Evaluate everything you read.** There are three ways of evaluating nonfiction. First, distinguish between reports and judgments. A report is a simple, verifiable statement of fact; a judgment is the author's own opinion, based, when valid, upon previous statements of fact. You must be careful not to accept a judgment as a report. Many authors, consciously or unconsciously, will try to persuade readers by masquerading one or many of their judgments as reports.

Next, evaluate every report and judgment on the basis of your experience and the information that is available to you. This is evaluating on external evidence. Finally, evaluate using internal evidence–the context of the article. Make sure that all facts are relevant and that each judgment is based on fact. In other words, make sure the author has a valid argument.

**Acquire the summarizing habit.** A collection of unrelated facts is of little value. But a background of integrated knowledge is your most valuable tool. Practice summarizing in writing, until it has become a mental habit. Jot down the main idea of each paragraph as you read. When you finish, you'll have an introductory statement, the main ideas, and a summary statement, all in one concise paragraph. This provides a framework for your ideas, which you then can retain more easily.

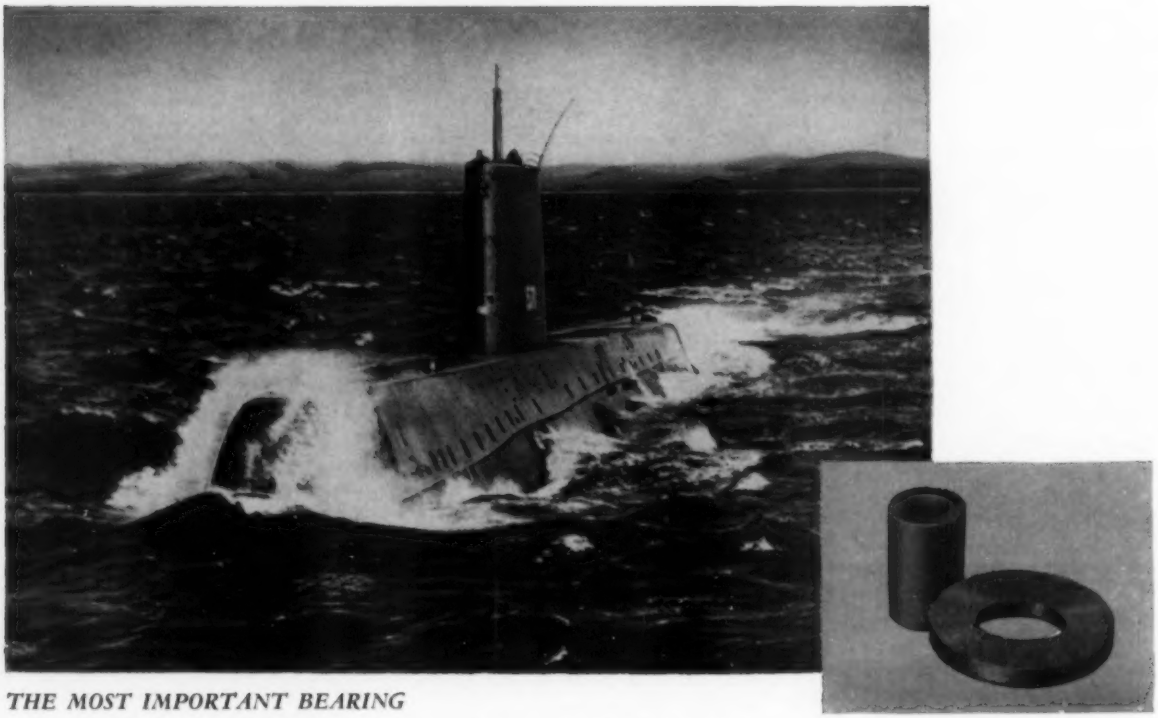
Summarizing is a further aid to concentration, since the summarizing process requires you to think constantly about what you are reading. You will learn to recognize main ideas and their relationship to one another, as well as to distinguish main ideas from insignificant details.

All of these habits are characteristic of the efficient reader. Faster reading rate, better comprehension, an increasing vocabulary, reading methods adjusted to purpose, constant evaluation of reports and judgments, and habitual summarizing–practice can turn these into invaluable parts of your reading skill.

**A more complete discussion of all aspects of reading improvement, plus practice exercises, is available in the book *Cut Your Reading Time in Half*, written by The Reading Laboratory and available for $1.25 from its publisher, Developmental Research Institute Inc, Dept E, 500 Fifth Ave, New York 36. To reserve a free reprint of this series write "Reading Lessons" on reader service card.**

*Are your seals or bearings subject to difficult operating conditions?*

# *GRAPHITAR® (Carbon Graphite) has the specific properties needed in difficult applications like these . . .*

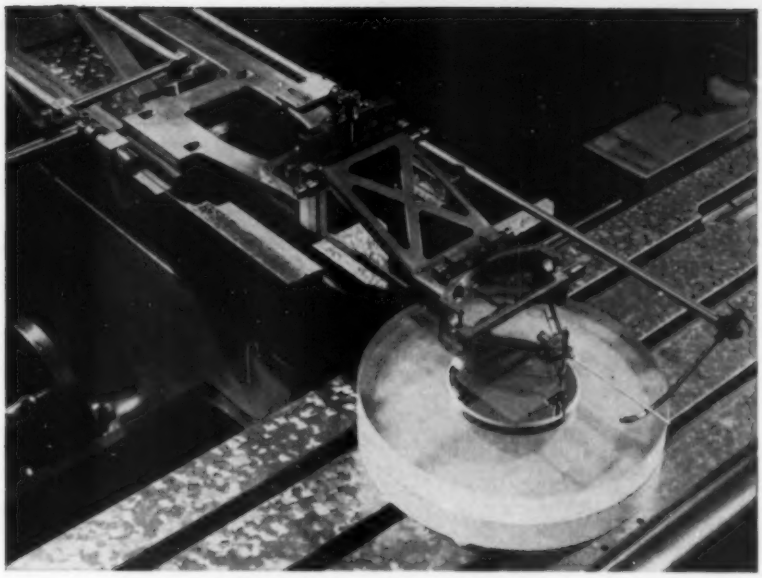


*THE MOST IMPORTANT BEARING*

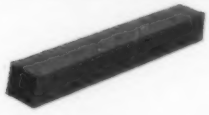
Dependability is vital in the power plant of the Navy's atomic submarine U.S.S. Nautilus which has steamed a total of about 50,000 miles of which approximately half has been submerged. In the reactor cooling system of the submarine, special "canned" motor pumps with integrated pump and drive motor were developed by Westinghouse. The bearings in these pumps, which are made of GRAPHITAR, must withstand high speeds, high temperatures, high pressures and must operate for indefinite periods of time without maintenance and with radioactive water as the only lubricant. Westinghouse Electric Corporation engineers—the builders of the Nautilus' atomic power-plant—find that GRAPHITAR is excellent for this difficult bearing application, because of its strength, durability, self-lubricating properties, and chemical inertness. If your design calls for superior bearings, consider the material that worked on such a demanding job.

**THE UNITED STATES**

GRAPHITAR® CARBON-GRAPHITE • GRAMIX® SINTERED METAL PARTS • MEXICAN® GRAPHITE PRODUCTS • USG® BRUSHES



## THE MOST EXACTING BEARING



The Bausch & Lomb Optical Co. of Rochester, N.Y., world renowned manufacturer of precision, scientific optical instruments, employs 10 GRAPHITAR bearings in its unique and highly specialized "ruling engine." The GRAPHITAR bearings provide dimensional stability within one-millionth of an inch for micro-inch accuracy in cutting 15,000-30,000 equidistant lines to the inch on 7" aluminized glass blanks to make diffraction gratings used by science and industry for spectroscopic analysis. Bausch & Lomb engineers have found that GRAPHITAR is unsurpassed as a bearing material where very close tolerances must be maintained and where frequent starting and stopping under heavy loads is a problem. These bearings have contributed greatly to the achievement of extreme accuracy in this application. If you require precision performance as was the case with a "ruling engine" why not use GRAPHITAR?

## THE MOST IMPORTANT SEAL

GRAPHITAR is the main shaft seal in the Pratt & Whitney J57 turbojet engine which powers many of our new aircraft, including the huge Boeing B-52 Intercontinental Bomber, which has eight of these turbojets. Naturally, the J57 must perform with utter dependability. One of the components of the J57 is the air/oil seal of GRAPHITAR on the turbine main shaft, and this seal is subjected to tremendous shaft speeds, as well as other taxing physical conditions. GRAPHITAR parts can stand severe operation because they are strong and are virtually unaffected by extremes of speed, pressure, and temperature. If your product develops high speeds or other difficult physical stresses on its parts, perhaps GRAPHITAR components could give it more dependable operation.

## THE TOUGHEST APPLICATION

Steel mills are famous for the rough, tough, heavy-duty jobs that they perform. In such difficult steel mill applications as bearings for shear and cut-off tables or coil and slab conveyors, metal-backed GRAPHITAR parts provide exceptional strength and durability. GRAPHITAR alone is a very strong bearing material, and when backed with metal has added resistance to shock. Because of its very low coefficient of friction, GRAPHITAR can operate under heavy loads at high speeds with no lubrication. Can the strength and superb bearing qualities of GRAPHITAR simplify your product design?

Get your copy of Engineering Bulletin No. 20.

GRAPHITAR is compacted from carbon-graphite powders under great pressures, then furnaced at heats near 4500°F. It can be formed in relatively complex shapes and ground to tolerances as close as .0005". For more information on this strong, light, self-lubricating engineering material, write for our Engineering Bulletin No. 20.

218

# GRAPHITE COMPANY

DIVISION OF THE WICKES CORPORATION, SAGINAW, MICHIGAN

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**CAMBRIDGE METAL-MESH BELTS** help you beat *today's* profit squeeze—give you the low-cost production and high product quality needed for the *competitive '60's!*

Combined movement and processing means metal parts, foods, ceramics or chemicals are processed faster, more uniformly—without costly manual handling. High product quality is maintained because heat, cold or liquids flow through the belt and around the product for thorough treatment. Cambridge Belts save on operating costs, too. Superior belt design and manufacturing techniques mean longer life, fewer repairs, lower operating costs. Belts can be made heatproof, coldproof or acidproof—in any mesh, weave, metal or alloy—with any side or surface attachments.

**Whether you're designing machinery for your own use, or for resale, the Cambridge Field Engineer in your area will be glad to discuss the many advantages of Cambridge Belts—from the manufacturing end to installation and service. Call him today. He's listed in the yellow pages under "Belting, Mechanical". Or, write for FREE 130-PAGE REFERENCE MANUAL.**

**The Cambridge Wire Cloth Co.**

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# now up to 400 h.p.

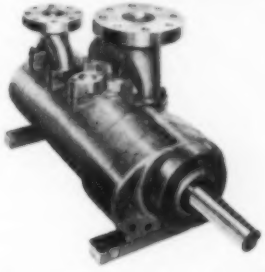
***instantly reversible!***

## *versatile drive from Berry Hydraulics*

### Adaptable to countless power transmission jobs

The unique rotating piston design of Berry Hydraulic pump/motors assures top efficiency and long life in rugged industrial service. These versatile fluid drives have been proved in such diverse power applications as dredge cutter-heads, heavy-duty cranes, marine cable laying equipment, sawmill cylinder carriage feeds and other uses.

Control flexibility possible with Berry Hydraulic Motors eliminates use of clutches, gears, brakes or complicated reversing mechanisms. This versatility makes them ideal for many power applications. Sizes to 400 H. P. are available from production stock to give you economical performance under your power and service requirements. Mail coupon for catalog. Ask for a free survey of your power problem by our experienced hydraulics engineers. Berry Hydraulics also offers a complete line of gear pumps from 1 to 76 G. P. M., pressures to 2500 P. S. I.



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- Maximum torque at stall
- Instantly reversible
- Carry overhung loads
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- Smooth, rapid acceleration and deceleration
- Dynamic braking action
- Multiple independent circuits from single unit
- Capacities from 5 to 400 H.P.
- Pumps can be used as motors or dynamic brakes without alteration

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General sales office: Oliver Building, Pittsburgh 22, Pa.
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Oliver Building, Pittsburgh 22, Pa.

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Can you recommend a drive for_____

# Here's Why···

## You Can't Afford Not to use Single and Polyphase Motors with KLIXON PROTECTORS

**Built-in Klixon Protectors in Single and Polyphase Motors Give You These Advantages**

- Elimination Of Motor Burnouts
- Increased Motor Output Under Adverse Conditions
- Simplified Motor Controls
- Reduced Motor Repairs And Replacement
- Reduced Production Down Time Due To Burned-Out Motors

KLIXON-Protected Motors are a sure way to keep today's rising operating and replacement costs down.

Built-in by motor manufacturers as an integral part of the motor, the KLIXON Protector saves money and reduces equipment down time by keeping motors operating at their maximum safe capacity under abnormal conditions. They enable you to get total output from your motors.

Built-in KLIXON Protectors safeguard your motors and prevent overheating and motor burnouts caused by the following conditions —

Prolonged overloads, unbalanced voltage, stalling, failure to start, increased ambient temperatures, lack of ventilation, plugging or reversing duty, single phasing.

Specify "KLIXON Protected Motors" on your purchase order . . . the savings are high . . . the advantages really worthwhile . . . the cost is low.

Full details may be obtained from your motor salesman; or write us for literature which explains the advantages of built-in motor protection.

**METALS & CONTROLS CORPORATION**
*Spencer Division*
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KLIXON®

# AlSiMag®

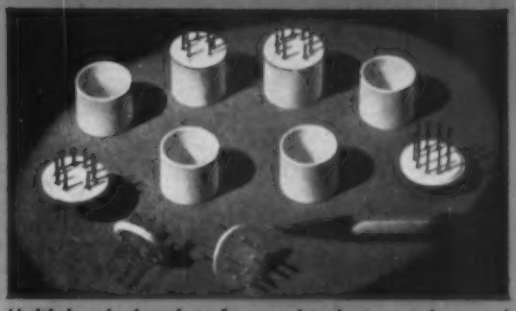
## CERAMICS and METAL-CERAMICS for MISSILES

AlSiMag high-alumina ceramics offer unusual reliability. High temperature resistance, superior insulating characteristics, great mechanical strength, resistance to abrasion, corrosion and chemical attack are among the advantages particularly important when maximum performance and reliability must be packed into minimum space.

Both soft solder and hard solder terminals are available. A new technique is producing strong high temperature metal-ceramic hermetic seals.

Precision tolerances can be maintained. Custom designs are made in an unusually broad range including ultra-thin or miniature components of unusual complexity.

AlSiMag special purpose compositions based on alumina, steatite, zircon, Forsterite, cordierite, titania, aluminum silicate, magnesium silicate, silicon carbide and other materials may answer special requirements. The AlSiMag family of ceramic compositions is the largest in the industry . . . and it is backed by more than half a century of specialized experience over the widest area of design and production in the technical ceramic field. Your inquiries will have prompt and interested attention.



Multiple pin headers for use in electron tubes and other demanding applications are made in AlSiMag with pins hermetically sealed. The AlSiMag ceramic may be safely used in working temperatures up to 2800° F. The limiting factors are the metal components. The parts shown have tantalum pins with nickel braze alloy combined with the ceramic in a strong hermetic seal for operating temperatures in the 1000° F. range. The materials have been carefully selected for ruggedness and for their low vapor pressure characteristics. This base and envelope allow higher bake-out temperatures during assembly.

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Illustrated is our latest Grinder for Spur and Helical Gears up to 72" diameter . . . ultra precision work table, accurate to 4.3 arc seconds total accumulative error . . . THIS MACHINE IS THE MOST ACCURATE LARGE GEAR GRINDER IN AMERICA . . . Ultra High Precision Gears ground on this machine open new horizons of accuracy and performance of Large Gearing for Radar, Marine, Turbine, Jet Engines, Diesel Engines, High Speed Shears and many similar applications . . . Phillie Gear has 5 additional High Precision Gear Grinders.

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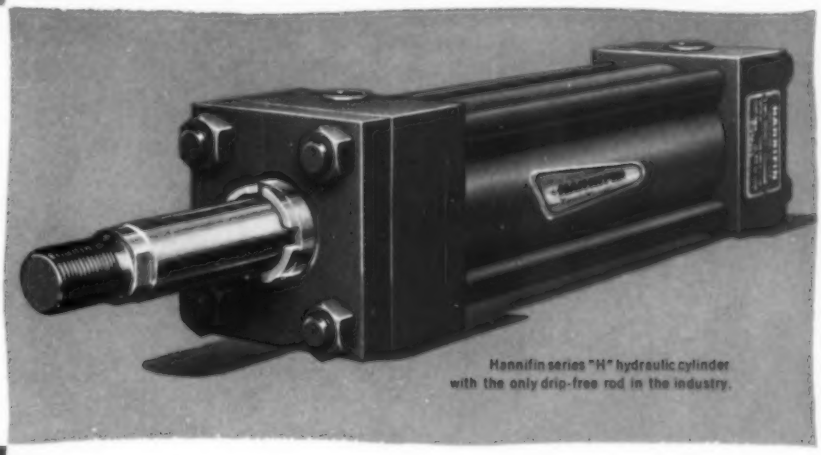
PARKER-HANNIFIN FLUID-SYSTEM COMPONENTS

Bronze cartridge gland with "LIPSEAL"® and "WIPERSEAL" can be easily replaced without dismantling cylinder.

# HANNIFIN

## hydraulic cylinders proved best by drip-free test



Hannifin series "H" hydraulic cylinder with the only drip-free rod in the industry.

Select either "drop-seal" piston rings (standard) for most applications or exclusive "LIPSEALS" where zero "clearance to air" is required.

No oil dripping on machine, product or floor proves complete sealing of oil within the cylinder by our removable, replaceable bronze cartridge gland with the exclusive "LIPSEAL"® and "WIPERSEAL" combination. (This new-type gland is shown close up at upper left.) This gland not only seals better, its long bearing surface is inside the seals where lubrication is assured.

Other Hannifin cylinder features include ground and polished rods hardened to an extra-deep case, then hard-chrome plated and polished again; cylinder walls "Tru-Bored" straight and perfectly round *before* being honed . . . PLUS 48-hour delivery on most standard Hannifin cylinders whenever required.

Your nearest Hannifin sales office or representative is listed in the A-Z volume of Thomas' Register. Call us in when cylinders figure in your designs. Or, for cylinder literature, write:

**HANNIFIN COMPANY**

515 South Wolf Road • Des Plaines, Illinois

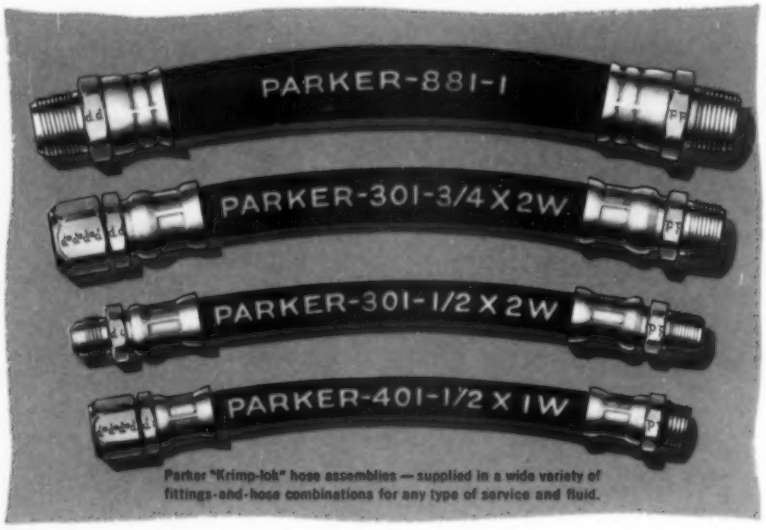
A DIVISION OF PARKER-HANNIFIN CORPORATION

## Now from Parker

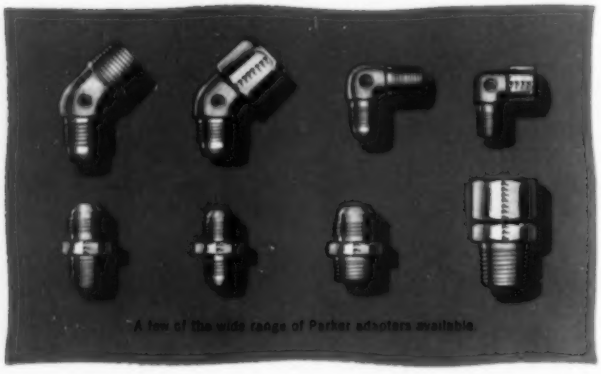
**BOTH permanent-end**

**and re-usable**

**hose assemblies**




Parker "Krimp-lok" hose assemblies — supplied in a wide variety of fittings-and-hose combinations for any type of service and fluid.



A few of the wide range of Parker adapters available.

You may require permanent-end hose assemblies for your production AND re-usable fittings with coils of hose for quick, trouble-proof replacements in the field. With the addition of Parker's new "Krimp-lok" fittings, permanent-end assemblies are now available from Parker. They use the same Parker hoses that enjoy a wide acceptance when used with Parker *no-skive* "Hoze-lok" fittings in the replacement field.

A full range of Parker adapters is also available.

Ask your Parker Hose Distributor, listed in the Yellow Pages, for engineering advice and literature on "Hoze-lok" re-usable fittings, also Parker hose and adapters. Write us in Cleveland regarding your requirements for Parker "Krimp-lok" Hose Assemblies.

Parker

FITTINGS AND HOSE

DIVISION

17325 Euclid Avenue

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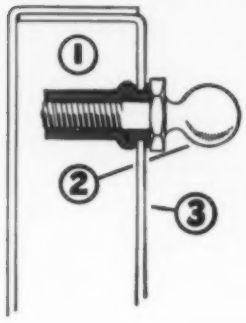
Parker "Hoze-lok" no-skive hose fittings and Parker hose, the ideal combination for short-run production and quick, reliable field replacement.

B.F.Goodrich

# B. F. Goodrich Rivnuts® solve 3 fastening problems at once!

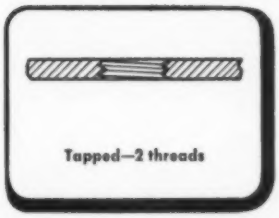


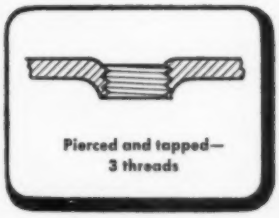

A RIVET WAS NEEDED for doors of metal cabinets that 1) could be installed from one side only, 2) would serve as a nut plate for a knob attachment and 3) could be installed after enameling. B. F. Goodrich Rivnuts proved the perfect answer.

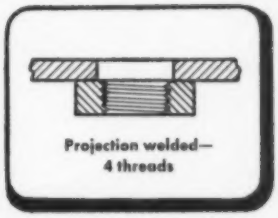
A flat-head Rivnut is inserted in the sheet metal door. Working from one side, one man can upset Rivnuts in seconds with easy-to-operate heading tool. Bulge formed in Rivnut shank grips the metal tightly. The knob of the catch is then threaded into the clean, still-intact Rivnut threads. Rivnuts are installed after enameling—without marring the finish.

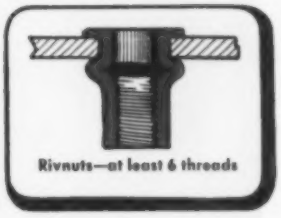
B. F. Goodrich Rivnuts, the only one-piece blind rivets with threads, save many man-hours on the job. If you have a fastening problem, why not put it up to B. F. Goodrich engineers?

***Compare these 4 methods of putting screw threads in thin sheet metal:***



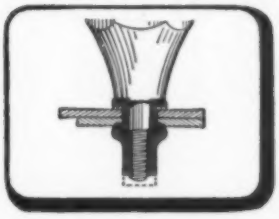



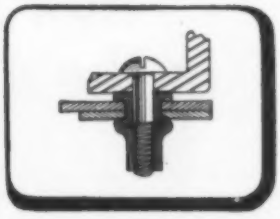

***Rivnuts provide at least 6 clean threads in one simple operation!***

**1** Rivnut is threaded onto pull-up stud of a manual or pneumatic heading tool.

**2** Rivnut is inserted—head firmly against work—tool at right angles to work.



**3** Tool lever operates pull-up stud, forming a bulge in the Rivnut shank.



**4** After upset, Rivnut threads are still clean and intact, ready for screw attachment.

## SEND NOW FOR FREE RIVNUTS DEMONSTRATOR

Demonstrates with motion how you can use Rivnuts to fasten TO and fasten WITH. Explains construction, gives proved applications. Write for your free copy today to *B.F.Goodrich Aviation Products, a division of The B. F. Goodrich Company, Dept. PE-29, Akron, Ohio.*

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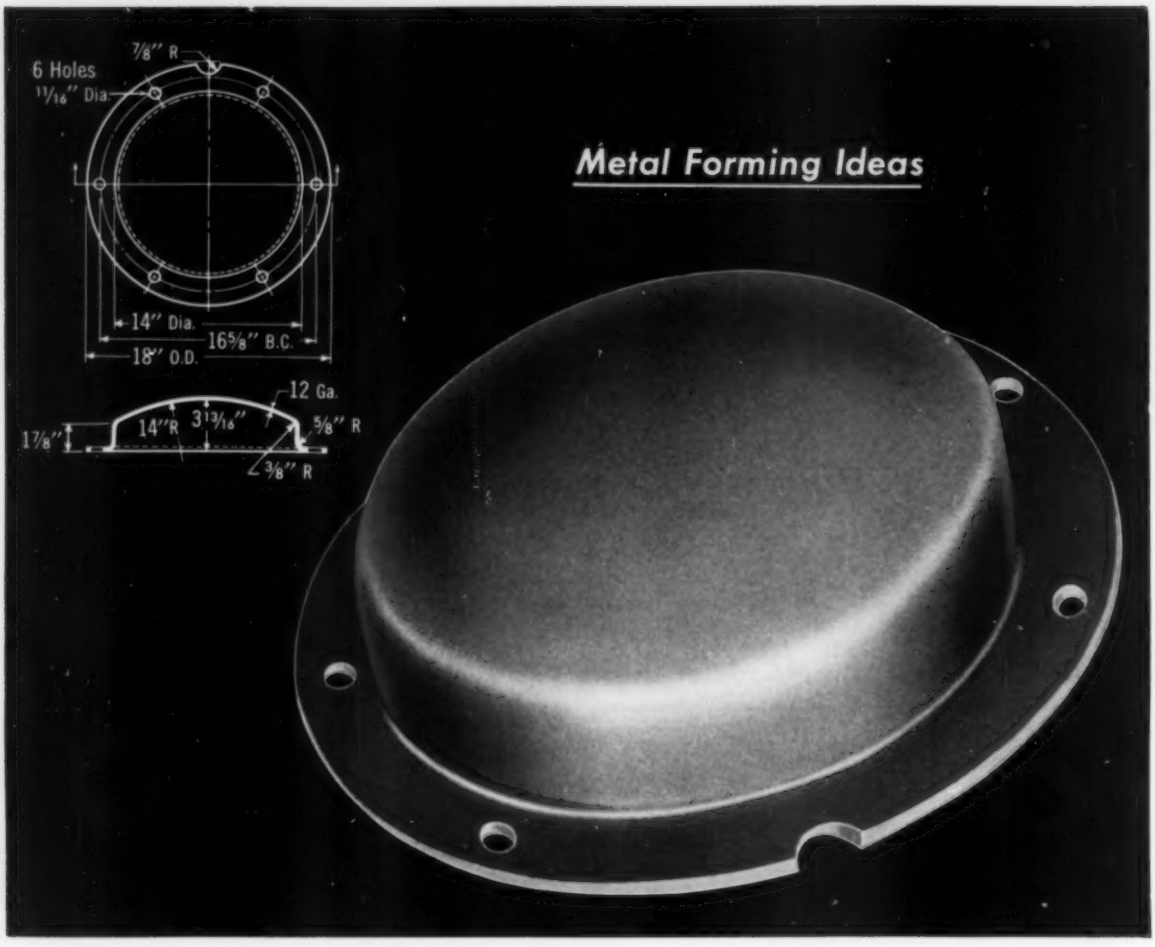



# How to eliminate special tooling in the design of custom-formed parts

Custom stampings, formerly prohibitive cost-wise, can now be inexpensively formed through the use of existing dies from COMMERCIAL'S "Die Bank" of almost 50,000 different forming die components.

A case in point: Wheel covers for American Coleman's aircraft towing tractor. They're important for the protection of the power transfer yokes in the tractor's four-wheel drive.

Stamping was first considered as the best method for forming them. The original low quantity involved and the amortization of $2,300 for special forming die costs, however, made the stamping unit costs impractical.

The covers were therefore first produced as machined, malleable iron castings at a cost of $8.49 per unit. A switch to hand spinning later reduced this cost to a still high $3.50 per cover.

American Coleman then discovered and investigated COMMERCIAL'S "Die Bank". From 24 basic shapes ranging 4" to 72" in diameter and involving metal thickness from 20 gauge to ¾" —all available through the use of existing dies adapted to presses up to 2000 ton capacity—emerged an entirely practical and economical solution to the unit cost problem.

The design: A standard, dished, offset shape with vertical and horizontal flanges and dish radius equal to its dished diameter. The wheel cover of 12 gauge, stamped steel now provides complete protection, necessary yoke clearance and a pleasing appearance.

Best of all, by using an existing forming die from COMMERCIAL'S "Die Bank", the actual tooling charge was only $80 for a simple modification of a single die component. And the unit cost was slashed to a practical $2.59.

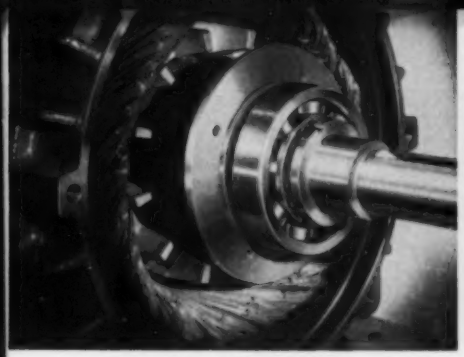
The final result: A strong, lightweight wheel cover with a smooth surface for finishing which now completely and economically meets all requirements.

If your component requirement involves a custom-formed or unusual shape, and if the high cost of tooling prohibits its economical forming, the "Die Bank" service at COMMERCIAL may be just what you've been looking for. There's a quick way to find out. Just send along a blueprint, sketch or prototype of your part to Commercial Shearing & Stamping Company., Dept. G-6, Youngstown 1, Ohio.

**COMMERCIAL**
*shearing & stamping*


CIRCLE 114 READER SERVICE CARD

CIRCLE 115 READER SERVICE CARD→



**HEAVY DUTY BALL BEARINGS . . .** The ball bearings used in these motors are of the highest quality, with more than ample capacity to provide long trouble-free service under heavy loads.

**BEARINGS CAN BE RELUBRICATED . . .** Original factory lubrication will last for years in normal service—but convenient grease plugs are provided to permit relubrication that adds to motor life under severe conditions.

**SECURELY SEALED FOR LOW MAINTENANCE . . .** Both ends of these motors have running shaft seals to keep the bearings clean. Bearing housings are effectively sealed to prevent escape of grease.

# Wagner Totally Enclosed Motors

## *Designed to give you Extra Protection*

**PROTECTED AGAINST CORROSIVE... ABRASIVE AND EXPLOSIVE ELEMENTS**

WM59-7

Here are motors that will deliver full-rated horsepower under the toughest service conditions—that will help you keep your production rates up, and give you the kind of dependable, continuous operation that is so important to automation.

Type EP Motors are fully protected against damage from corrosion, dust, abrasives, fumes, steel chips or filings. Type JP is explosion proof as well—is designed and approved for use in explosive atmospheres.

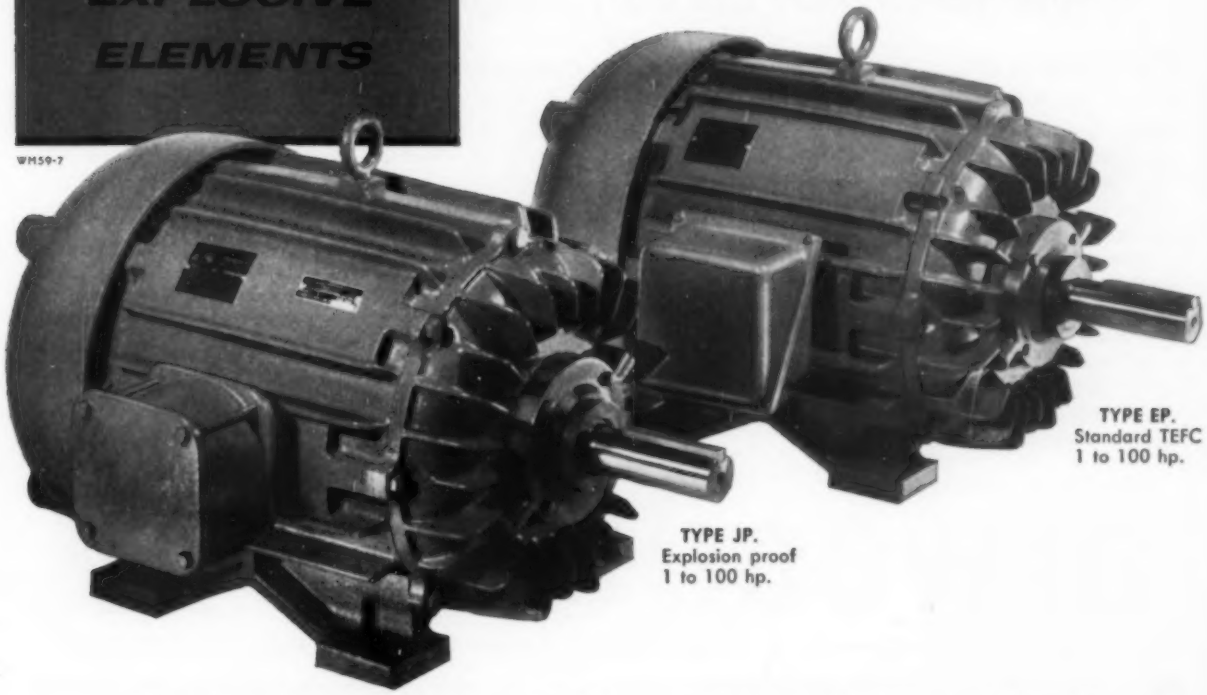
Integral ratings, 1 through 100 horsepower, are built in the latest NEMA frames, 182 through 445 US, with ribs that add mechanical strength and increase the surface cooling area.

Let your Wagner Sales Engineer show you how these protected motors can bring you savings on initial motor costs, maintenance costs, and in continuity of operation.

**Branches and Distributors in All Principal Cities**

**Wagner Electric Corporation**

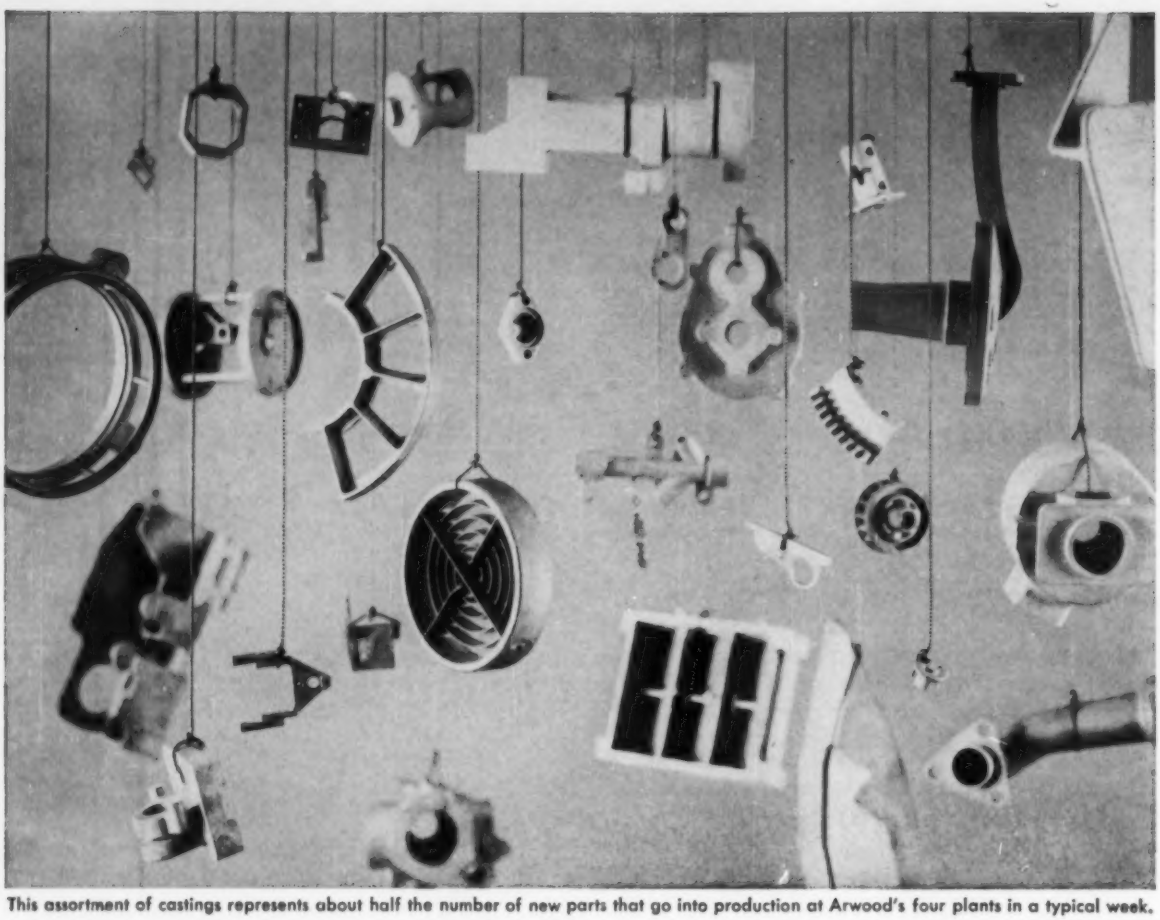
**6406 Plymouth Ave. • St. Louis 14, Missouri**



**TYPE EP.**
Standard TEFC
1 to 100 hp.

**TYPE JP.**
Explosion proof
1 to 100 hp.

OTHER FRAME SIZES AVAILABLE IN RATINGS THROUGH 500 HP.



This assortment of castings represents about half the number of new parts that go into production at Arwood's four plants in a typical week.

# Arwood solves twice this many design problems each week!

## *Could Investment Casting help you?...a prompt answer is yours for the asking*

Upon receipt of a drawing or sample of your part, Arwood will give you a prompt, honest appraisal, spelling out exactly what we propose to furnish. We will also suggest minor design changes that may save you money without affecting the part's performance.

Arwood can handle the complete job, from design and tooling through to finish machining, in any castable metal or alloy. Arwood assumes complete responsibility . . . your procurement problems are at an end.

Arwood's four fully-equipped production plants and well-staffed tool rooms are geared to give fast service. Each job is individually scheduled to assure you of delivery of finished castings in the shortest time possible.

Large and small companies come to Arwood for quotations at the rate of fifty a day . . . without obligation. Why not let us help *you* evaluate the potential savings you may realize by making your part an Arwood investment casting?

**Write today for your free copy** of the new 44-page Arwood Manual of Investment Casting. Provides all the information you need to evaluate the technique and use it to help solve your design problems.

# arwood

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*A complete service from design through tooling, production and finish machining. Sixty-two engineering consultants from coast to coast.*

PLANTS IN BROOKLYN, N. Y.; GROTON, CONN.; TILTON, N. H. & LOS ANGELES, CALIF.

# Want to be an Executive?

**Management is actively looking for engineers who have the desire and ability to become administrators**

by
**James M. Jenks**

In a sense, this is the golden age for engineers. Once buried in corporate obscurity, many of them have emerged today as likely heirs apparent to the big jobs — and the big rewards — of business and industry. One impressive indication of this growth is that money spent in research and development over the past fifteen years has increased six-fold.

Despite this stepped-up activity, however, the once disorganized scramble for engineers seems to have ended . . . at least temporarily. And perhaps it's a good thing. Actually, the more perceptive engineers had always realized that unusually high starting salaries were often illusory. The gap between money being offered beginners and the incomes of experienced men was narrowing rapidly. Further, more and more thinking technical men concluded that even top engineering salaries are low when compared with the remuneration of highly placed general executives.

### A Plan to Help the Engineer Succeed

Happily, there is a route to increased incomes that is satisfying to both engineer and company alike. This route leads into *management*. It is no easy road but the rewards are great for those willing and able to follow it.

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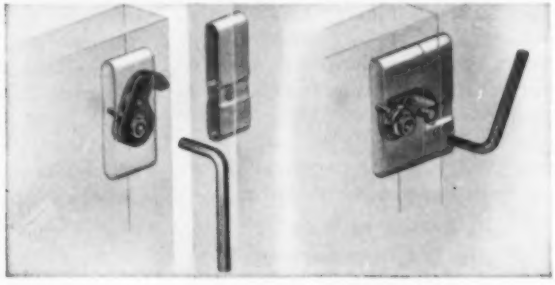

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# PERSPECTIVES

## in design and development . . .

### *Needed: Measurement Specialists*

Wanted—a corps of measurement specialists to provide the many instrumentation and measurement techniques needed to solve the battery of special scientific and engineering problems in today's research. These professional measurement scientists would, according to Dr Allen V Astin, director of the National Bureau of Standards and proponent of the plan, reduce the inefficiencies that take place when a nonspecialist takes time out to learn the business of precision measurement, where, he says flatly, "it is possible to select almost any point from basic research to production and say that it exists on the edge of precision knowledge."

Take the area of the newer basic scientific investigations. Dr Astin says novel measurement techniques have been developed in the nuclear field, but much of today's confusion has been compounded by seemingly contradictory observations. Another "basic frontier" of measurement is in the field of ionizing radiation, i.e. plasma physics. Ionized gases show great promise as sources of tremendous power and as envelopes for great natural furnaces, says Astin, but it is apparent that in this field theory is running well ahead of measurement capabilities. Main obstacle: lack of precise techniques for producing, controlling these phenomena in the lab.

The area of "free radicals" also depends directly upon the future refinements of measurement techniques. At present, NBS is cooperating with scientists from industry in working toward such measurement.

There are many measurement problems in the established fields of science. But Dr Astin feels the popular look at research does not reveal the fact that some of the most profound problems facing science are those related to achieving higher precision where substantial precision already exists. For example: in spite of gains made in the field of spectroscopy, which have provided the basis for most of our knowledge of the molecular, atomic and nuclear structure, there are many problems whose solution would be accelerated with improved measurement techniques, such as with the beta ray or infrared spectroscopy.

### *Time, Temperature and Automation*

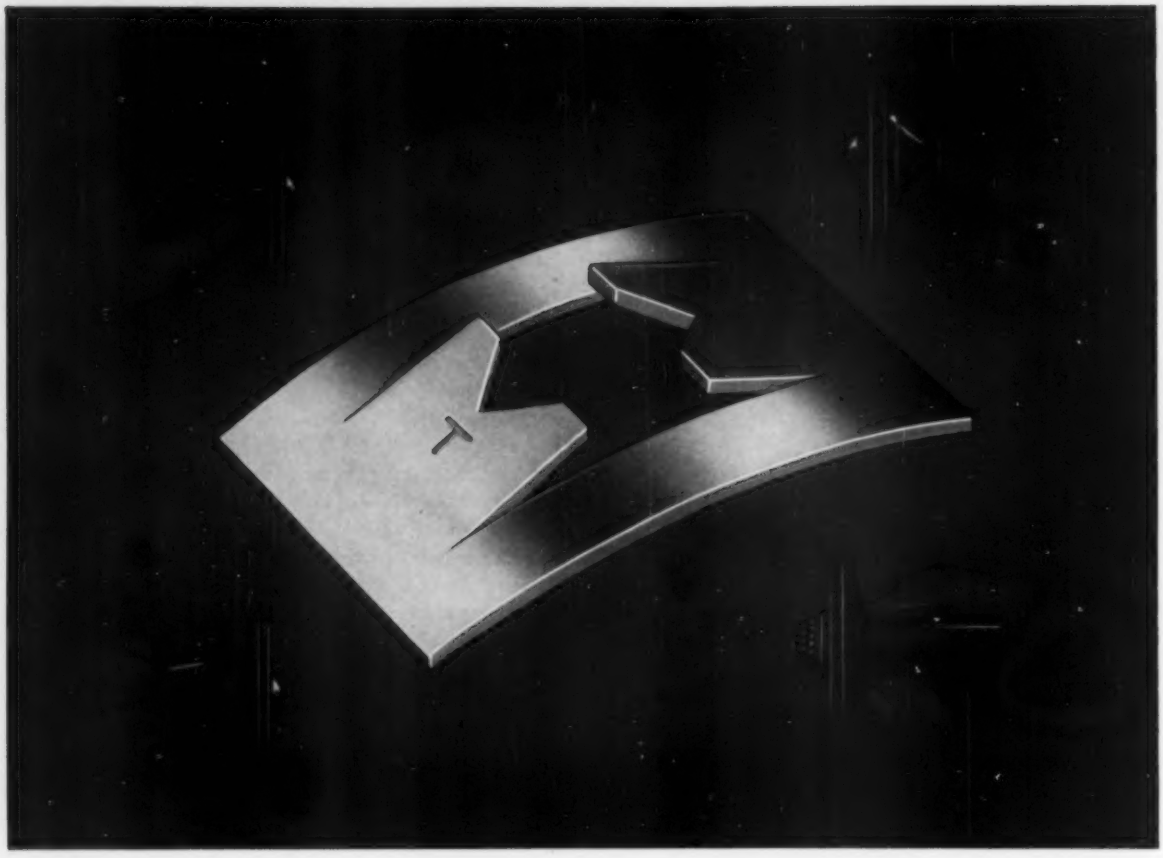
Time-measurement techniques is another area, says Dr Astin. The cesium beam and masers permit measurement of extremely short intervals, or minute rate changes over long periods. Dr Astin says, "It soon may be possible to put a sufficiently sensitive atomic clock in a satellite to make a direct check on the postulate from the general theory of relativity concerning the influence of the gravitational field on atomic process."

Temperature measurement is still another problem. Under controlled laboratory conditions, NBS can measure "with some confidence" up to 6000 C. "Yet today," Dr Astin says, "we are talking about million-degree temperatures and the possibility of controlled-fusion furnaces." Measurement at the extreme opposite end of the scale is similarly difficult.

The field of automation is a bright one, Dr Astin feels, but is still a frontier. Automation equipment more often than not is short of perfection. Computational and control techniques must be developed as well as a rational system of interrelated instrumentation for total automated control.

In the area of established technology, the problem of component reliability faces an increasing number of parts and components in new equipment, particularly missiles. These are just a few areas of importance. Dr Astin can list many more.

—Paul Anderson



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**Product Engineering** **HORIZONS**

February 2, 1959

# ". . . It's what we know that ain't so"

In Athens, Dr. Derek J. Price of Cambridge, England, has just identified an object brought up from the depths of the Mediterranean on Easter Day, 1900, by a sponge fisherman. Resting in the Greek National Museum as a curiosity, it turns out to be a highly precise mechanical model of our solar system. Intricate gears, turned by a small crank, keep the sun, moon and planets in proper relative position when they are rotated. Yet the model was made in 65 BC–2000 years ago!

As Dr. Price says, "Finding a thing like this is like finding a jet plane in the tomb of King Tut." What happens to all those stories about Watt inventing the crank, the relatively recent development of gear engineering, and the painstaking series of discoveries that supposedly gave us our knowledge of the solar system? So Christopher Columbus turns out to be little more than a copyist with his "world is round", as well as only a later visitor to our shores–preceded by Phoenicians, Norsemen, and who knows who else!

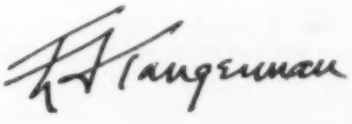
Such discoveries are disquieting, because they strike at the basis of our knowledge–the first "facts" we learned in school. Gradually we come to learn how many pieces of knowledge that supposedly we thought were the "discoveries" of our civilization are actually only rediscoveries of knowledge lost in the series of conquests and dark ages our earth has undergone.

As the latest Russian addition to our solar system makes its endless orbit around the sun, will it meet other satellites put there by man? Will it meet other space ships of earlier civilizations, or of other worlds, perhaps long gone? Has it carried some earth-born virus free of our atmosphere so it can flourish in outer space? If so, will it wipe out competing forms of "life", as measles and other diseases of the "civilized" white man wiped out "primitive" peoples when we "discovered" them? Or are there just too many "stars" outside our minor galaxy at the edge of the Milky Way?

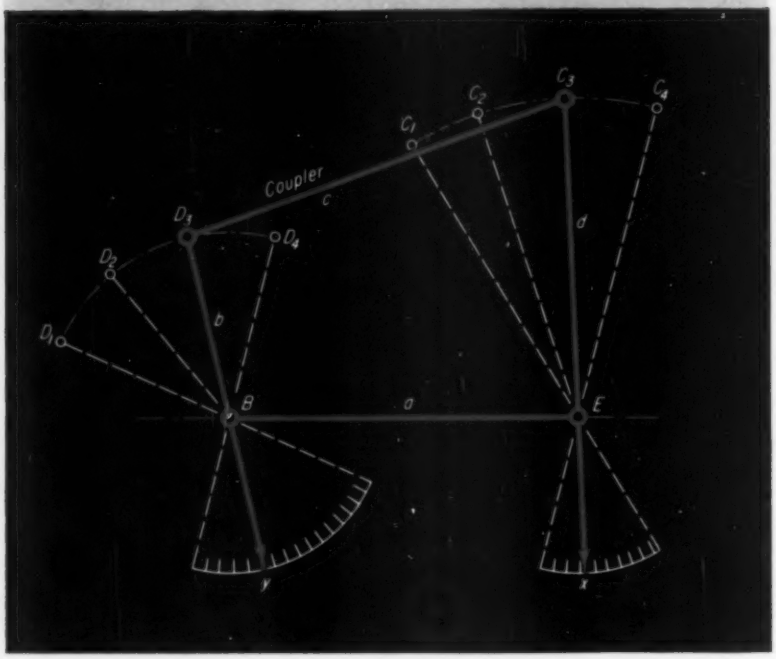
These were all fantastic questions a year or two ago. They are no longer, for we begin to see how very little we really know. Our education may have helped close our eyes to fact as much as it supposedly opened them, for most of our time is spent learning the things that cannot be done, because no one before us could supposedly do them.

Many of these negative "facts" were learned by observation–and we know now that observation can be faulty too. The things we see "with our own eyes" may not be so either. For a simple example, take the case of the giraffe. Our West Coast editor recently sent me a lyric statement that, contrary to what I've seen with my own eyes, a giraffe's front legs are only as long as his hind ones–his body is so much thicker in the chest, and the legs "attach" so much lower down, that the obvious visual inference is the wrong one. A couple of zoologists I know had made the same visual error as we laymen, so it's nothing to be particularly ashamed of. But it is something to think seriously about in our bland acceptance of a whole series of "facts of life". If we can't even observe a giraffe correctly, why should we assume our other observations are sound? And we can smile no longer at that old fable of the blind men and the elephant.

Abe Martin said it once, some years ago, with: "It ain't what we know that's important, it's what we know that ain't so."



**1 Four-bar linkage . . .**
employed as function generator. Angular positions of links *b* and *d* correspond to desired function, $y = f(x)$.




# better than trial and error . . . GRAPHICAL SYNTHESIS of FOUR-BAR LINKAGES

**The author's methods simplify the development of linkages to generate specific functions. Also supplied are working examples that illustrate the three basic problems and show how to solve them.**

ROLLAND T HINKLE, *Professor of Mechanical Engineering, Michigan State University*

Something better than the textbook method is needed when designing a four-bar linkage with a definite application in mind. Instead of starting with proportions of a linkage, then deciding what it will do, you can use synthesis: the required motion is specified first and the appropriate linkage then determined by a planned approach (as contrasted with trial and error).

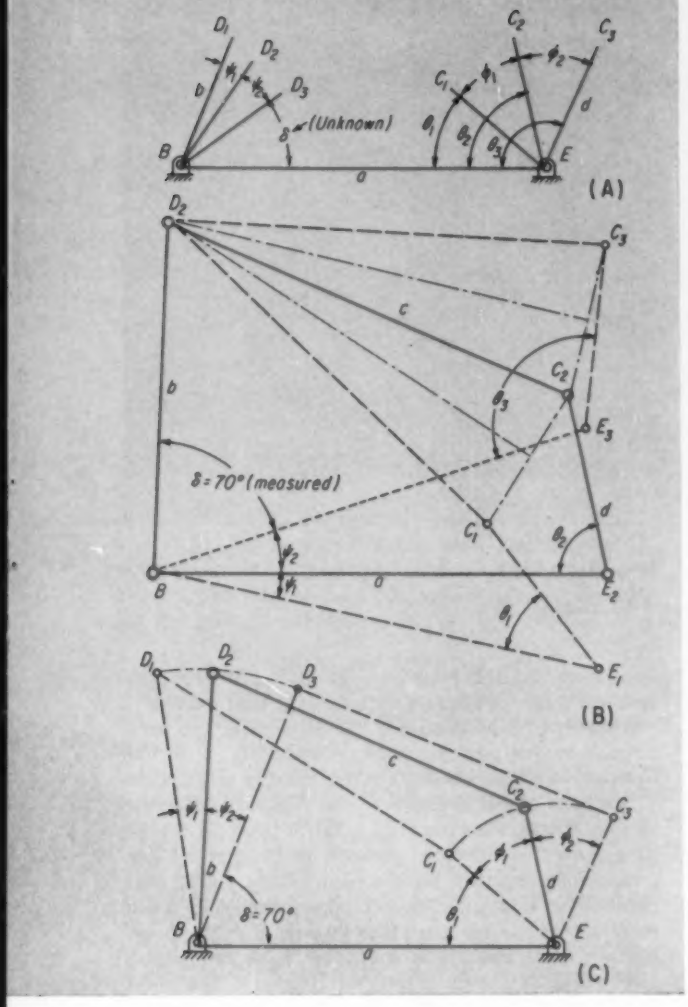
Synthesis can be either graphical or analytical. The trend has been to analytical synthesis because of the accuracy required in most function-generating applications, such as computers. But graphical synthesis, on which little has been published in English, gives sufficient accuracy for many applications. Moreover it gives a better feel for the mechanism—it shows what actually is taking place.

Because a variety of functions can be generated, it is more practical not to depend on a single, over-all procedure. Hence, a choice of three basic methods that can lead to a good solution are given here, along with examples. In each a 4-bar linkage is called on to generate approximately, but over a specified range, the function, $y=f(x)$. A typical linkage, Fig. 1, has one fixed link **a**, and one acting as a coupler, c. The angular positions of links *b* and *d* then represent the variables. The design is made by specifying a number of exact positions that satisfy the functions: for example when link *b* is at $D_1$, link *d* is to be at $C_1$. Usually the linkage will not generate the function exactly between these points—but among the methods one will give a workable answer.

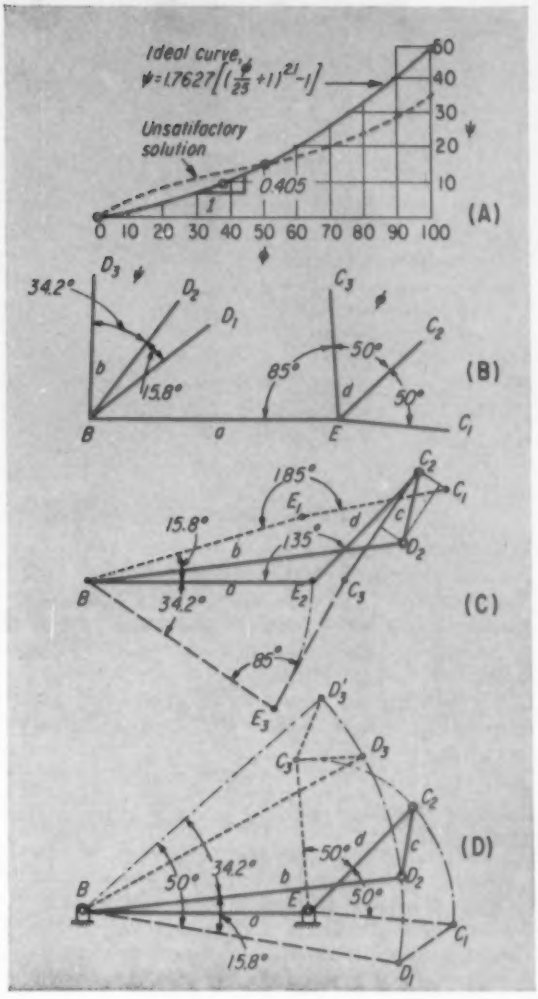
## I—METHOD OF PERPENDICULAR BISECTORS

A 4-bar linkage is to satisfy three precision points—$D_1C_1$, $D_2C_2$ and $D_3C_3$ shown in Fig. 2(A).

Thus when link *b* is at position $BD_1$, link *d* is at $EC_1$,




**2 Perpendicular-bisector method . . .**
satisfies three positions of links *b* and *d*. Problem is shown in (A), construction details in (B), and final linkage positions (at reduced scale) in (C).




**3 Function generation . . .**
of power curve shown in (A) performed by 4-bar linkage; position requirements are laid out in (B), construction details in (C) and (D). First solution, dotted in (A), is unsatisfactory. Solution using slope method is too close to ideal curve to plot.

etc. Some assumptions must be made to get started. These are: the lengths of links a and d, and the initial angle $\theta_1$ for link *d*.

The linkage is constructed with the aid of inversion by which stationary link *a* is permitted to move (because its length has already been assumed), and link *b* is fixed in any one of its three precision points.

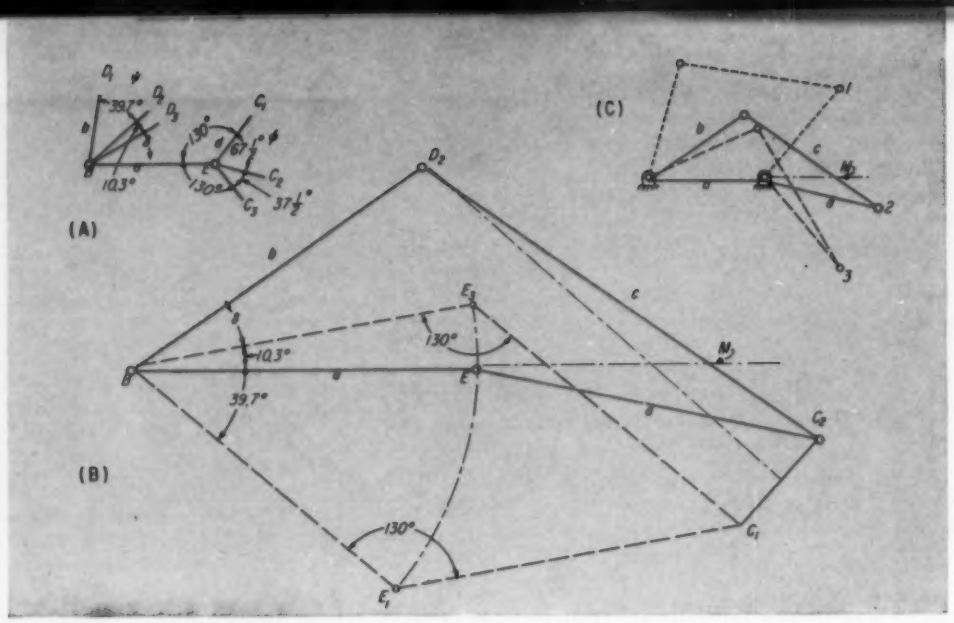
Construction details are shown in (*B*). Link *a* is laid out, then link *d* is laid out at the known angle $\theta_2$. This gives point $C_2$. Now link *a* is shifted an angle $\psi_1$ to position $BE_1$. (Angle $\psi_1$ is measured clockwise instead of counterclockwise because of inversion.) Laying out angle $\theta_1$ and the length of link *d* locates point $C_1$.

This procedure is again repeated: laying out angles $\psi_2$ and $\theta_3$ locates point $C_3$. The three points, $C_1$, $C_2$ and $C_3$ determine a circle with center at $D_2$. Point $D_2$ is now located by drawing the perpendicular bisectors of $C_1C_2$ and $C_2C_3$. This gives link *b*. The desired linkage is $BE_2C_2D_2$ and the initial angle δ is 70°. The completed linkage with link *a* fixed as the frame link is shown in (C) in the three precision positions.

### Special Case—Function Generator

A 4-bar linkage is to approximately generate the function $y = x^{2.1}$ where *x* is to have a range from 1 to 5, corresponding to 100° of crank rotation, with precision points at 1, 3, and 5. The output link y is to move through 50°.

The linkage is to generate this function in terms of the chosen angle ranges; thus *x*, varying from 1 to 5, is to be represented by an angle $\phi$ which varies from 0 to 100°, and y which varies from 1 to $5^{2.1}$ or 29.366, is to be represented by angle $\psi$ which varies from 0 to 50°. The equation in terms of these angular ranges




**4 Linkage layout . . .**
for angle-bisector method shows desired positions (A), construction details (B), final linkage positions (C).

is determined as follows:

$$x = \left(\frac{x_{max} - x_{min}}{\phi_{max}}\right)\phi + x_{min} = \left(\frac{5-1}{100}\right)\phi + 1$$

$$y = \left(\frac{y_{max} - y_{min}}{\psi_{max}}\right)\psi + y_{min} = \left(\frac{29.366-1}{50}\right)\psi + 1$$

Substituting these values for $x$ and $y$ in the original equation gives:

$$\psi = 1.7627\left[\left(\frac{\phi}{25} + 1\right)^{2.1} - 1\right]$$

Graph of this equation is plotted in (A) of Fig. 3. The precision points corresponding to x = 1, 3, and 5 are: $\phi_1 = 0°$, $\psi_1 = 0°$; $\phi_2 = 50°$, $\psi_2 = 15.8°$; $\phi_3 = 100°$, $\psi_3 = 50°$.

These values are shown in (B) where it is assumed that the function increases as $b$ moves in counterclockwise direction. The assumed orientation of the precision positions for link $d$ is indicated by the 85° angle.

Construction details are shown in (C) of Fig. 3 where inversion about link $b$ was again arbitrarily chosen in the second position. Lengths for links $a$ and $d$ were arbitrarily chosen as $BE_2$ and $E_2C_2$. Point $C_3$ was located by rotating link $a$ 34.2° clockwise while maintaining the 85° relative position of $a$ and $d$. The arbitrarily chosen length of $d$ is also maintained; thus $E_2C_2 = E_2C_3$. Point $C_1$ is located similarly. Perpendicular bisectors of $C_1C_2$ and $C_2C_3$ intersect at $D_2$, giving the desired linkage, $E_2BD_2C_2$.

The linkage is now shown in Fig. 3(D) with link $a$ fixed and link $d$ moving through its 100° range. The values of $\psi$ for each 12.5° increment of $\phi$ have been plotted in (A). From this can be seen that the linkage is not satisfactory; in fact, the third precision point is not even reached. The reason is seen in (D). The joint at $D_2$ must be disconnected, then reconnected at $D'_2$ to give the correct precision point. This change, of course, would affect the other positions; hence an unsatisfactory solution. A new ratio between links $a$ and $d$ must now be chosen and the procedure repeated. Another way is to select new precision points, (see the next example).

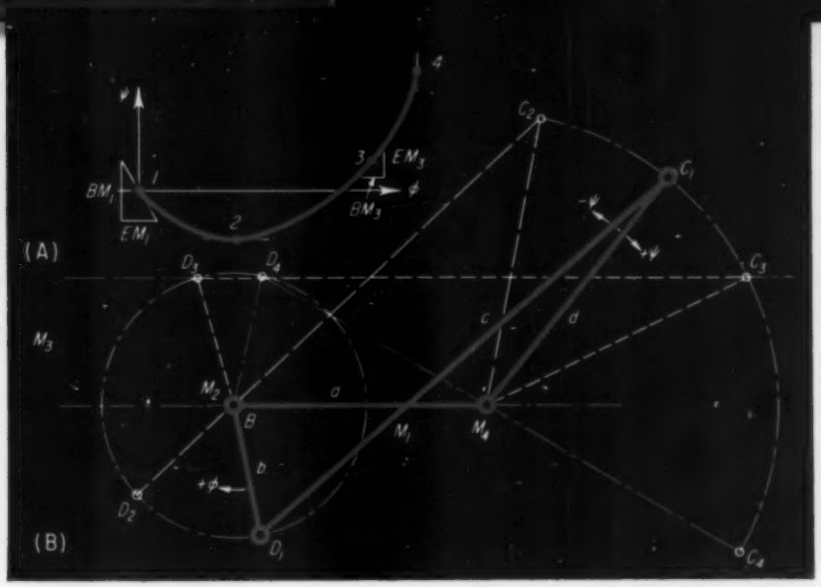
Thus there is no guarantee that the linkage can even move from one precision point to the next. Very few functions can be generated exactly. Shaffer and Cochin ("Synthesis of the Quatric Chain When the Position of Two Members Is Prescribed," ASME paper 53-A-144) have derived a differential equation which they call the compatibility equation for the 4-bar linkage. With this equation it is possible to determine whether a given function can be generated exactly over a finite range. Further, if the function is compatible, these two authors give equations for designing the linkage. But most functions are not compatible over a finite range. A 4-bar linkage will generate exactly only certain transcendental functions.

## II—ANGLE-BISECTOR METHOD

It is often more desirable to have a linkage that will closely approximate the desired function over the entire range than be exact at only a few points. For example, the middle point of the previous example is shifted, resulting in: $\phi_1 = 100°$, $\psi_1 = 50°$; $\phi_2 = 37.5°$, $\psi_2 = 10.3°$; $\phi_3 = 0°$, $\psi_3 = 0°$. The initial angle for link $d$ is chosen that the extension of link $a$ bisects the angle between one pair of points—in this case, angle $C_1EC_3$, (A) of Fig. 4. This avoids assuming a length for link $d$, as was done in the previous examples.

Solution is shown in (B). Length of link $a$ is arbitrarily chosen and laid out. Angles 10.3° and 39.7° determine points $E_2$ and $E_1$. Two 130° angles can now be laid off to determine point $C_1$. This is because of symmetry resulting from bisecting the angle—causing $C_1$ and $C_3$ to coincide. This is called point-position-reduction.

Length of link $d$ is now known and $C_2$ is located by making $EC_2 = E_2C_1$. Point $D_2$ can now be arbitrarily chosen on the perpendicular bisector of $C_2C_1$. This will give a solution.




**5 With slope method . . .** derivative of desired curve is inversely proportional to divided segments of link c.

A closer approximation to the ideal function can be obtained by choosing a fourth precision point which will give a second perpendicular bisector—its intersection with the first giving a definite location of $D_2$.

### III—SLOPE METHOD

A good approximation can be obtained by specifying the slope at one of the precision points (in this example, it is the second precision point.)

Assuming the same function-generator problem, and its equation, the derivative of the equation is:

$$\frac{d\psi}{d\phi} = \frac{(1.7627)\ (2.1)}{25}\left(\frac{\phi}{25} + 1\right)^{1.1}$$

Substitution of $\phi = 37.5$ in the above equation gives $d\psi/d\phi = 0.4055$.

Now, it is known that in 4-bar linkages the ratio between velocity of driver and follower is inversely proportional to the segments which the line of transmission (the coupler link c extended) cuts on the line of centers. This point of intersection $M$ is also the instant center of links $b$ and $d$. Then

$$\frac{d\psi}{d\phi} = \frac{\omega_b}{\omega_d} = \frac{EM}{BE + EM} = 0.405$$

Point $D_2$ in Fig. 4 (B) can now be located by the slope method. Assuming a length for $BE = 6$ in. then from above equation, $EM = 4.09$ in. After plotting $M$, a line is drawn through $C_2M$, intersecting the perpendicular bisector of $C_2C_1$ at $D_2$. This completes the desired linkage, which now satisfies three precision points plus one slope. The method has given results within ½° accuracy. The linkage in the three positions is shown in (C).

The reason why second precision point was changed from that of the example in Fig. 3 is now apparent. If link $d$ and the extension of link a coincide, the solution is indeterminate.

#### Velocity-ratio analysis

The velocity-ratio theorem can serve to indicate the slope of the function that the linkage can generate. For example, the linkage shown at (A) in Fig. 5 can generate the curve (B).

At position $D_1$ of the input link $b$, link $c$ intersects the line of centers at $M_1$, giving a negative slope ($b$ and $d$ rotate in opposite directions when $M$ lies between the centers) of $BM_1/EM_1$. At position $D_2$ links $b$ and $c$ are colinear giving a zero slope; thus a small displacement of $b$ will not cause an appreciable displacement of $d$. At $D_3$ the coupler is parallel to the line of centers, making $M_3B = M_3E$, which gives a slope of one. As $b$ approaches $D_4$, a small displacement of $b$ will cause a large displacement of $d$, and in the limit when $c$ and $d$ are colinear, the slope is infinite. This is a theoretical limit and cannot be reached in practice.

Some rules can now be developed by analyzing Fig. 5:

- A positive slope requires that the coupler (link c) intersects the line of centers ($BE$) outside of the centers.
- A slope of 1 requires that the coupler be parallel to the line of centers.
- A negative slope requires that the coupler intersect the line of centers between the centers.
- A slope of –1 requires that the coupler intersect the line of center midway between $B$ and $E$.
- Zero slope means colinearity of input link and coupler.
- An infinite slope requires that the output link and coupler be colinear (the theoretical limit).

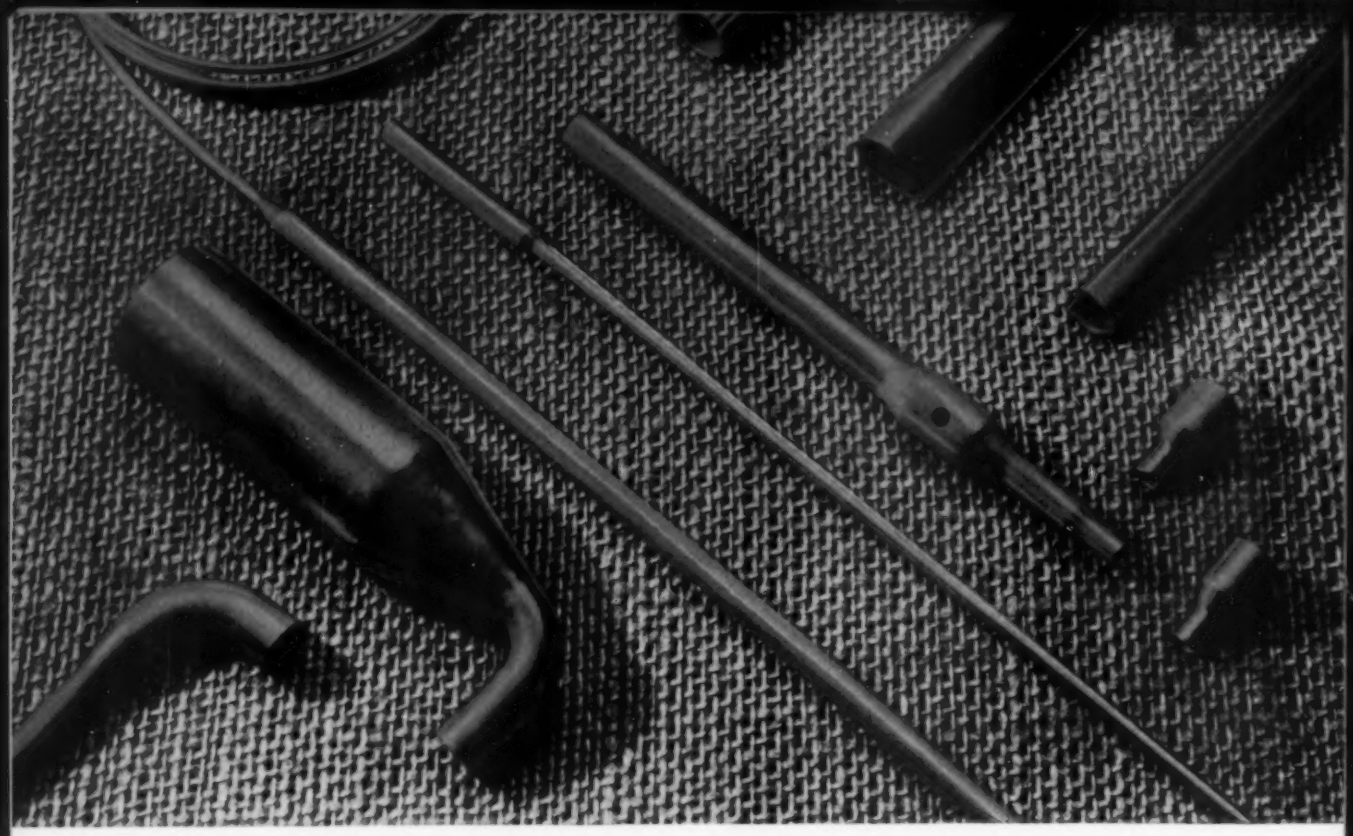
The graph of a function can then be examined to determine some of the characteristics of the linkage. Coordinates of a point on the graph give the relative angular displacements of links $b$ and $d$, and the slope gives the point where the coupler intersects the line of centers. In some cases it will be obvious that a 4-bar linkage cannot even approximately generate the function.

**REPRINT** of this article can be obtained for your reference file by checking E65 on one of the Reader service cards bound in this issue. For further reprints available see "Current Reprints" listing in this issue on page 96.

**EDITOR'S NOTE:** For every linkage there are two substitutes that will produce same desired motion. See "Roberts' Law Helps You Find Alternate Four-bar Linkages," Oct 27 '58, p 54.

Often overlooked is the importance of good joints. For a survey of available types, see "Linkage Joints," Dec 8 '58, p 87.

If a linkage is to perform only upon demand, a clutch can be avoided by employing a roll cam to do the job. See "Rollcams —They Stop and Go on Demand," Jan 19 '59, p 68.



# COPPER ALLOYS

## for Those Small Tubular Parts

**Easily drawn, swaged, flared, pierced, bent and joined—copper alloy tubing can be shaped to solve many design problems. Here are the ground rules for best results.**

D S GRANNISS, *Application Engineer, French Small Tube Div, The American Brass Co*

To meet the needs of automatic manufacture, copper alloy tubing is now being drawn with closer tolerances and greater lengths than ever before. This is leading to a renewed interest in finished parts formed from small tubing—for products like room air-conditioners, machine tools, instruments, and household appliances. But efficient design of tubular parts goes beyond purchasing a pair of bending blocks and flaring tools. Here is a quick review of the guiding principles for these shapes—including some important but little-known tricks to simplify design, lower costs and improve performance.

Small tubing, in this context, means any diameter 1 in. or less—down to the $\frac{1}{8}$-in. size that gives restrictor elements in modern refrigerating equipment. Most of the small parts are made from tubing $\frac{3}{8}$ in. dia and smaller—with a wall thickness of 0.020 in. or lighter. Thicker walls are a must at $\frac{1}{8}$ in. dia and below because of the very low stiffness afforded by such diameters.

In its manufacture, small tubing is drawn through a die to reduce OD, and over a plug to reduce wall thickness. A floating plug is used for very long coils that are drawn on a block. Reduction is limited to the amount needed to bring the tube to specified hardness (usually Rockwell 15-T scale), breaking strength, tensile or yield strength, or percent elongation. These characteristics have much more meaning than the usual temper terms "half-hard" and "quarter-hard," and are preferred when specifying the tubing or the parts made from it—to ease fabricator's understanding of designer's intent.

Tube shapes other than round are usually harder to draw, particularly where the ID has a different shape from the OD. Such shapes are made by drawing through a die and over a plug, and require several forming operations—plus stress-relief at the final stage because of non-uniform metal flow around the perimeter. Many non-round shapes like ovals, half-ovals, half-rounds or flat-ovals—any shape not requiring sharp corners—are made by roll-forming. Here, a round tube is passed through a

## TO BEND TUBING—COMPARISON OF 4 FILLERS

| MATERIAL | ADVANTAGES | LIMITATIONS |
|---|---|---|
| Sand | Low cost<br>Easily obtainable<br>Compacts well | Time-consuming<br>Hard to remove |
| Salt | Low cost<br>Easily obtainable<br>Compacts well<br>Dissolves in water | Time-consuming<br>Residual corrosive |
| Rosin | Low cost<br>Melts readily<br>Easily recovered | High melting point<br>Can irritate eyes |
| Low-m. p. metal alloys | Low melting point<br>Low molten viscosity<br>Expands slightly when solid<br>Removable in boiling water | Relatively expensive<br>Adheres to Cu-Ni alloys |

## MIN COLD-BEND RADII FOR ANNEALED COPPER AND BRASS TUBING (IN.)

| Tubing OD, in. | Class A Optimum Conditions ($D/t < 15$) | Class B Commercial Work ($D/t < 50$) | Class C Without Mandrel ($D/t < 30$) |
|---|---|---|---|
| 1/8 | 1/16 | 1/4 | 1/2 |
| 1/4 | 1/8 | 5/16 | 1 |
| 3/8 | 3/16 | 3/8 | 2 |
| 1/2 | 1/4 | 7/16 | 3 |
| 5/8 | 5/16 | 9/16 | 4 |
| 3/4 | 7/16 | 11/16 | 6 |
| 7/8 | 1/2 | 3/4 | 8 |
| 1 | 9/16 | 7/8 | 10 |

Note: Class A & B require conforming bending block and mandrel; Class C needs only cylindrical block.

series of four pairs of shaped rollers that give the desired cross-section. Shapes thus formed are very straight.

### FABRICATING THE PARTS

Bending is the most common forming operation for making parts from tubing. For round tubing much the best way—fast, cheap and versatile—is with commercial bending tools. Here, the shape of the section is maintained either by inserting a round-nosed mandrel or with a snug-fitting block and shoe that surround the tube at the bend point. For non-round tubing, bending tools can be used—but the shape must be supported by an appropriate filler to minimize flattening and wrinkling. The most common filler materials are compared in the upper table. Some thinning occurs on the outer fibers of even perfect bends, but extensive tests have shown sufficient work-hardening occurs to increase the bursting strength of the tube.

Proper bend design requires adherence to several simple rules:

**Keep tolerances on bends consistent** with temper of the material, and size and flexibility of the part. Thus, very close tolerances on the opening of a U-bend with very long straight sides are senseless unless the material is at least half-hard and the tubing of large diameter. Otherwise, any desired opening tolerance can be had at installation simply by springing the bend.

**Two adjacent 90° bends** require some straight length between them to permit purchase for the bending tools—unless special tooling is provided. Adjacent bends in the same plane should be separated by a straight length of twice the tube diameter, whereas two bends in planes at right angles require about 4D.

**U-bends that go beyond 180°** should be made from ordinary 180° bends sprung during installation, otherwise tooling becomes very expensive. Good example is a serpentine coil for a heat-exchanger: bends greater than 180° are often specified to save space—a costly design that can be avoided by adding a secondary forming step to the drawing that shows installation of the part.

**Keep within the minimum cold-bend radii** listed in the accompanying table. In Class A bends, bending blocks and shoes must fit the tube contour precisely and

the mandrel must be precisely where the bend will be made. Class B require good fit and adjustment, though not the extreme care of Class A, and filler material can be substituted for the mandrel. Class C can be made without mandrel or filler and with very little external mechanical support. Though these values are listed for annealed tubing, tempers up to half-hard can be bent to similar radii by an experienced fabricator.

**For minimum distortion** after bending, do not expect non-round to do as well as round shapes. This is particularly true when tube ID and OD are different in shape. Overlooking this point can lead to trouble: a recent heat-exchanger coil was fabricated from half-round brass tubing rolled with the flat side out for maximum contact area when soldered to the shell. But rolling this way made the flat side concave, leaving a natural trap for residual chlorides from the solder flux–a condition that led to early stress-corrosion cracking.

**Unbalanced residual stresses,** either from drawing the tube or forming the part, are troublesome–they lead to "season cracking" if the unrelieved part operates in certain chemical environments. Alloys containing more than 15% zinc tend to be bad actors here, along with the silicon bearing alloys in the hard state. This does not imply that only dead soft alloys are safe, but rather shows the need to watch out for potential unbalanced stress situations, and to specify appropriate relief annealing if called for. For example: copper readily lends itself to swaging, expanding, flaring, and beading–but to perform the same operations on the brasses usually requires one or more intermediate anneals. Regardless of alloy, stamped identification markings–a common source of residual stress–should be avoided.

**Mechanical vibration** causes fatigue failure in many tubular parts because one of the following three factors is overlooked: sufficient flexibility, usually in the form of excess length, must be provided between fixed ends; soldered joints should not be overannealed, as excessive grain growth forms a focal point for fatigue failure; parts should be stress-relieved before installation if there is any possibility that the forming operation introduced unbalanced stresses.

## OTHER DESIGN GUIDES

**Beading** is a common way to provide a stop when two tubular parts are joined, or when the formed parts must be positioned accurately in an assembly. These raised ridges running around the circumference can be rolled in over a mandrel if the tubing OD is $\frac{3}{8}$ in. or above. Below $\frac{3}{8}$ in. the mandrel is too thin and flexible to do the job, nor is there room enough for removing it after beading. An alternate method for small diameters is to "press" the bead by upsetting the tube along its axis. Here, a grooved ring die surrounds the tubing so the metal has some place to flow. Best diameter tolerances on rolled beads are about ± 0.006-7 in. These cannot be held with the pressing method–it is harder to control and needs closely squared tubing ends for accurate results.

**Single dimples and matched-die gouging** on the outer surface are two simple alternatives to beading where positioning can be less precise. In the former, a mandrel with a single point is used; for the latter, two half-round die blocks containing protruding pins are brought together on the OD, and the edges of the pins nick the surface. This method is limited to tubes with wall thicknesses over about 0.025 in.

**Holes** in the walls of tubular parts can be drilled at any point, but burr removal can run up costs. Piercing will give burr-free holes but only in the area adjacent to a free end. The largest pierced hole practical has a diameter equal to half the tubing OD, and must be centered no further than twice the tube diameter from the free end. These restrictions are set by needs of chip removal and mandrel stiffness.

**Cutting** of light-wall tubing, without leaving a burr, can be done with a sharp circular saw at high speed. Best for most jobs is a 6-in.-dia blade with 184 teeth, though any blade with fine teeth will work. For softer alloys, speeds are from 2400 to 5000 rpm–the higher speeds being for the lighter walls. For the refractory alloys like silicon bronze, phosphor bronze and nickel silver, speeds are lowered to 400-600 rpm. Chrome-plating the blade and applying light machine oil improves the cut and also the life of the saw.

**Joining** two formed tubular parts can be done mechanically, with flare- or compression-type fittings–or by soldering or brazing, with wrought copper or cast brass fittings. Often fittings can be eliminated by belling the end of one tube and inserting the other tube. Service temperatures for soldered joints go to about 250 F, with brazing taking over above this temperature.

**EDITOR'S NOTE:** Some of the points raised in this article are covered in greater detail in the following recent articles:

"One Temperature for Successive Brazes," Dec 8 '58, p 84—how tighter production control with special brazes allows multiple brazing, without reducing operating temperature of the final assembly.

"The Case for Swaging," Nov 24 '58 p 70—recently introduced swaging machines have increased the usefulness of this high-speed method for shaping metal; author gives tips on materials, shapes and tolerances.

"Stress Corrosion in Metals," Aug 4 '58, p 56—stress plus chemical environment can make it tough for some alloys to resist cracking; here are the characteristics of this delayed-action damage, and some design steps to head it off.

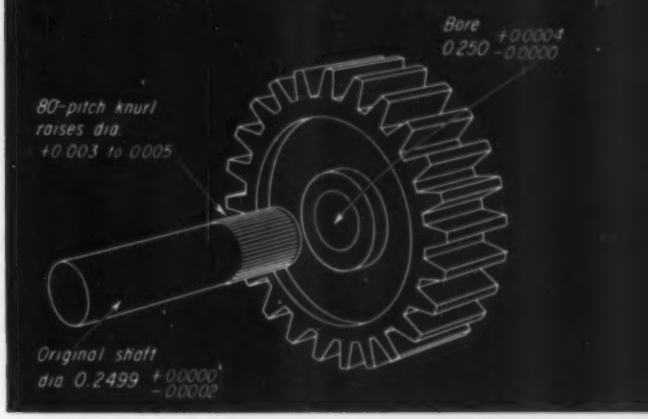

### Your Index is Ready

The Product Engineering Index for the last half of 1958 is now available. It covers all editorial material published in the 26 Design and R & D issues between July and December 1958. In addition to feature articles and staff reports–both staff written and contributed–the Index covers major items in all staff-written departments, and an author index. A separate listing includes all organizations and company references.

To obtain your copy without charge write "Index Vol 29-II" under the "Free Reprints" space on the Reader Service Card in this issue.

A HOW-TO:

# SMALL SHAFT Becomes Its Own Broach for Retaining Gears




**Tolerances** on stainless steel shaft and aluminum gear before assembly.

**This neat method developed by the author also keys links to shafts in such applications as computing devices.**

WILLARD J OPOCENSKY, *Staff Engineer, Librascope Inc, Glendale, Calif*

In this fastening technique, a knurled shaft does its own broaching and keys itself into a close-fitting hole. This avoids need for press fits or locking devices when retaining gears and links on small shafts.

The method, being applied to assemblies where shaft size is ¼ in. or under, has these definite advantages:

- It does not take up space nor does it weaken or distort parts by the machining of grooves or holes.
- It is inexpensive, simple and requires no extra parts.

Here is how the method works when self-broaching an aluminum or brass gear onto a stainless steel shaft.

The shaft is machined to a tolerance of plus zero minus 0.0002 in. Bore of gear is made to a tolerance of plus 0.0004 in. to minus zero. These tight tolerances may not be needed in other applications as they are employed here mainly to get high concentricity.

The shaft is now given a full 80-pitch knurl. Shaft diameter, gear thickness and knurl width are equal. Knurling increases shaft dia by 0.003 to 0.005 in.

A chip groove is then cut at the leading edge of the knurl. This cut, made cleanly at right angles to the axis of the shaft and to a depth of a few thousandths, sharpens the teeth of the knurl so that it acts as a broach when pressed into the hole—the groove provides space for the displaced chips.

The method has also been tested with steel shafts up to ¼ in. dia in aluminum and brass links for electromagnetic computing devices; and it was found that the shaft can be twisted until it snaps off at the chip-groove with no evidence of loosening of the joint. Thickness of the link has, in all cases, been equal to shaft diameter. It has been estimated that a 20- to 30-lb pull is required to remove a shaft or gears. There will be variation in pull depending on the materials. The holding power can also be increased by increasing the width of the knurled area or heat-treating the shaft before assembly to permit using harder gear link materials. However, the pull-out force should not be too high or it will increase possibility of distortion when disassembly is required.

## Application in a Differential

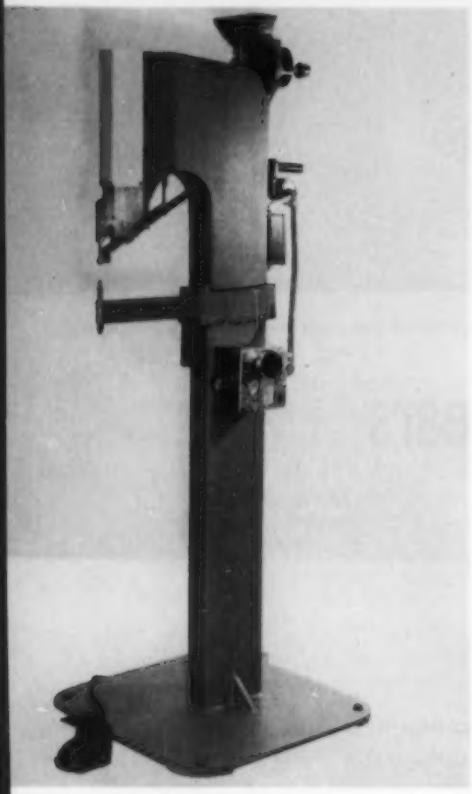
The knurl-broach method is used in a differential to retain gears that must withstand a temperature range of −65 to 160 F.

Several factors complicate such an assembly problem, and rule out other methods. The side gears are specified by customers, are usually added after the differential has been assembled, and are often too thin to permit using pins or setscrews. Also, cutting through the gear to insert a pin, key or screw would cause loss of concentricity when thermal expansion took place; and the pressure exerted by a screw would bring further distortion. The precision needed in many applications of the differential assembly—in computers, flow totalizers, fire-control mechanism and other high-accuracy instrumentation—requires that no distortion be present.

Again, an 80-pitch knurl is used to increase the shaft hub dia 0.003 to 0.005 in. Although the differential is designed for max torque of 12 in.-oz in the gear train, the bond between the hub and gear will withstand over 800 in.-oz of torque.

If one of the ring gears has to be replaced, it is only necessary to clean out the chip-groove before installing a new one. This can be done at least twice with no measurable loss of bond strength.

Because the knurl-broach method gives strength far in excess of the application requirements, it has not received much mathematical analysis. Considering that a full-depth knurl is used in all cases, and that the self-broaching feature insures exact mating of the shaft and the hole, it should be possible for the theoretically-inclined to apply conventional gear formulas to determine the resistance to torque. ■

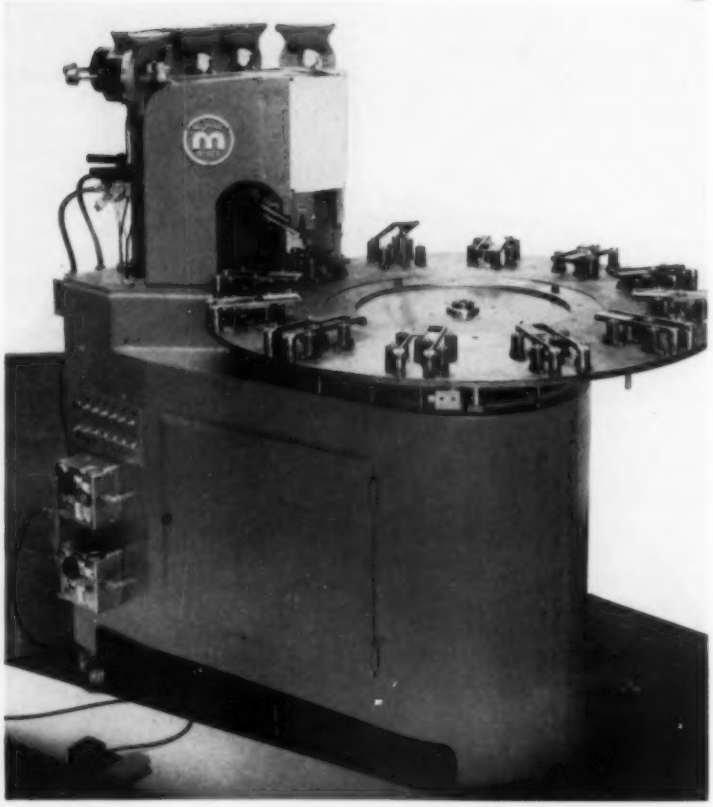


**The variable stroke-velocity and pressure of this riveter allow setting fasteners in materials of low impact strength. And the narrow-headed unit allows spacing them closer.**

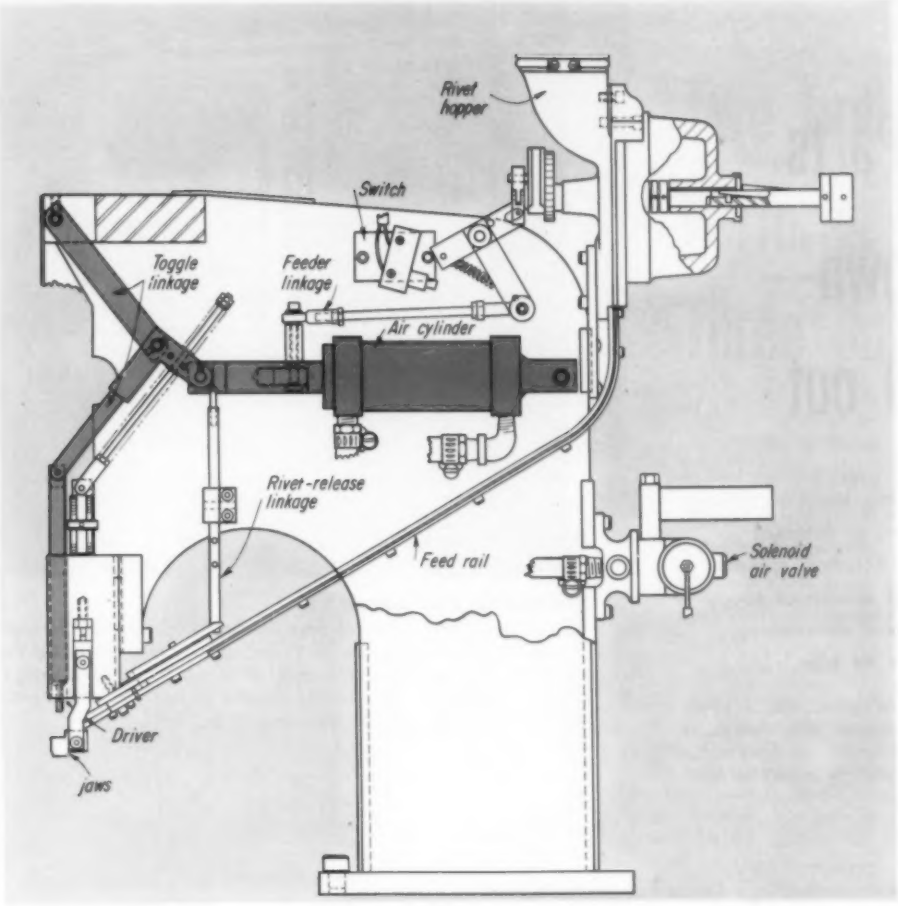
Riveter can be had as single unit on pedestal but is designed primarily for multihead installations on a common base and coupling by a slide or rotary fixture. With standard units, center distances between heads can be as little as ¾ in.; but with driver and jaws offset, spacing between rivets can be reduced to little more than rivet head dia. Model No. 56 head weighs 90 lb, handles rivets from 1/16 to 5/32 in. dia and from 3/32 to ¾ in. long. Produced by Milford Rivet & Machine Co, Milford, Conn.

# Rivets Fit Closer, Go In Easier

**Single head . . .**
on this pedestal has offset driver and jaws. Offset permits riveting under flanges and within 3/32 in. of vertical surfaces. The air-pressure control, mounted with lubricator on side of pedestal, regulates pressure behind operating stroke. Welded steel frame of riveter has no projections on either side, so adjacent units can be flush-mounted in multihead machines.

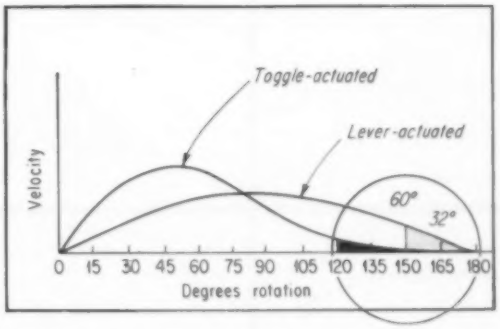


**Typical multihead . . .**
machine has 5 of the riveter heads bolted to common base. Rotary table has 12 positions each with 5 anvils and a cam-operated ejector to remove parts after riveting. The 2 side-mounted combination units control air pressure and lubricate air cylinders.




**Rivet head . . .**
is powered by air working up to 125 psi. Air entering blind end of air cylinder forces piston rod and its extension to left, straightening the toggle linkage, and forcing down the driver and spring-loaded jaws. Driver pushes rivet through jaws and sets it against anvil (not shown). Piston-rod extension connecting air cylinder to toggle linkage has 2-cam surface that trips rivet release. Single rivet is released from feed rail at each stroke of riveter. Rotary rivet-feeder is driven by linkage between piston-rod extension and hopper mechanism. At full stroke, hopper linkage contacts switch which reverses stroke of air cylinder to retract driver and jaws.

Velocity of driver is controlled by restricting discharge of air from rod end of piston. Driver pressure is controlled by setting operating air pressure to produce desired force.



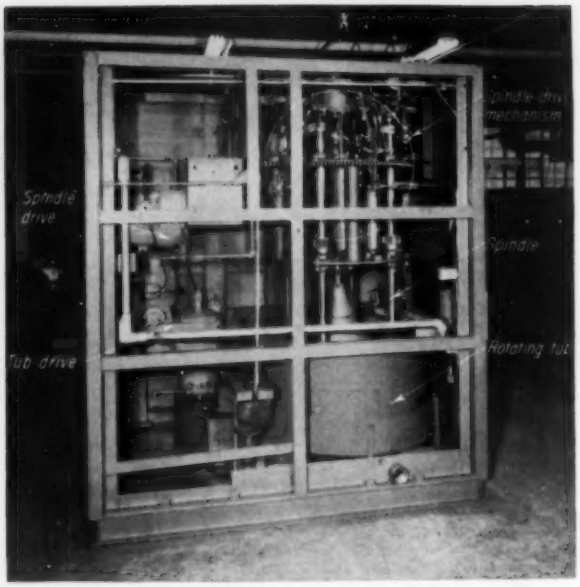

**Velocity curves . . .**
for toggle and for lever-actuated riveting machines, both crank-driven, compare velocities of drivers for each type machine. Shaded area under each curve represents same linear motion for each driver, therefore same expenditure of energy, and indicates number of degrees of crank rotation during actual setting of the rivet. With the toggle, expenditure of the energy over a much longer period of crank rotation indicates a much lighter force required to produce same effect as the lever.

While curve shown for the toggle does not apply directly to a pneumatic drive, it is this lighter force requirement which has made possible the compact design of the Model 56.

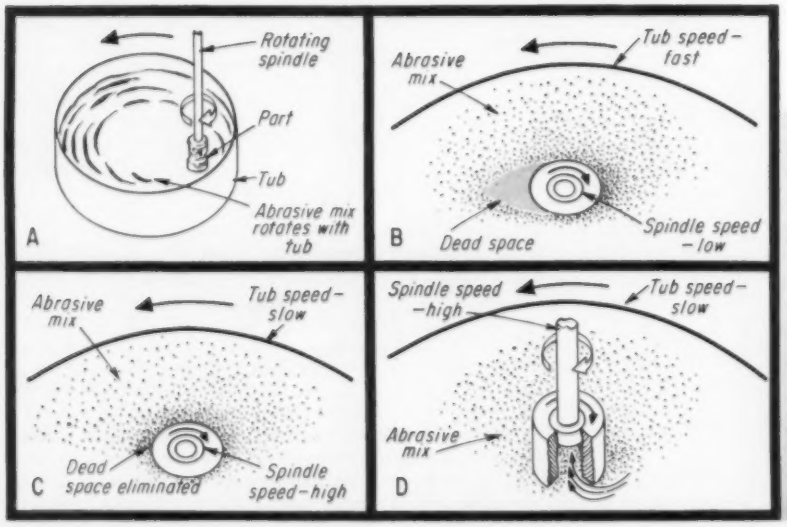
# Spinning Parts Get Rubdown— inside and out

**This polishing-deburring machine finishes depressed outer areas, or internal ones such as bores. Rotating spindles hold parts in whirling stream of soupy abrasive. Relative speed determines where abrasive takes its bite.**

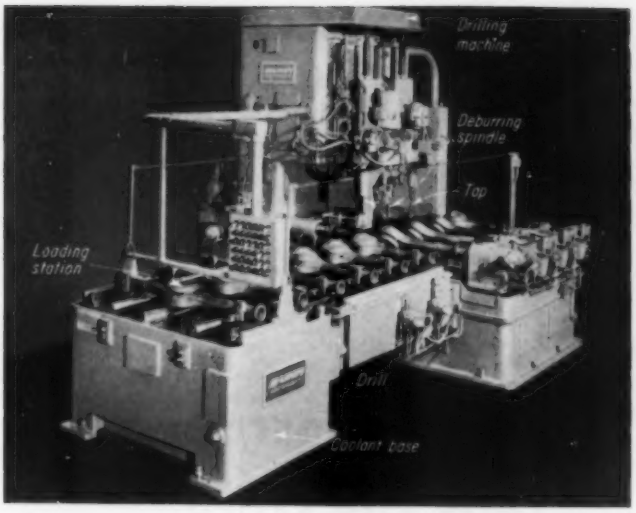
Working at production-line pace, the 4-spindle machine is a complete package, with controls to vary spindle and abrasive speeds for wide range of applications. "Rotomatic" is made by Roto-Finish Inc, Kalamazoo, Mich.




**Removing side panels . . .** shows multispindle drive of 4-spindle deburring machine. Separate variable-speed drives rotate the spindles, and tub containing the abrasive mix; permitting wide range of speeds for different applications. Opening at right permits operator to load and unload parts at the end of the polishing-deburring cycle.

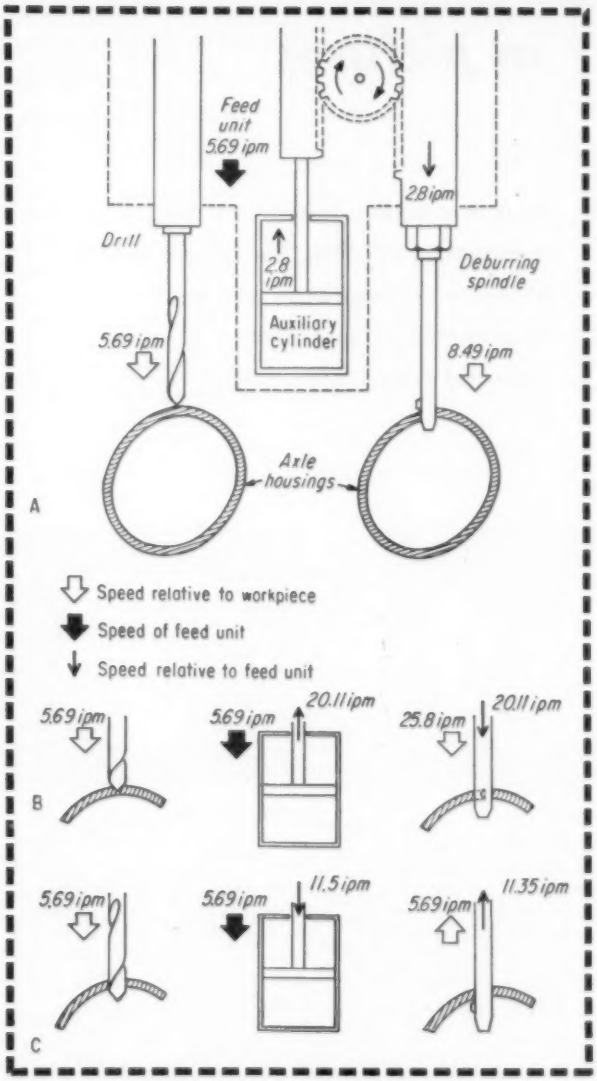


**Polishing and deburring . . .** of a part depends on rotational speeds of tub and spindles. Relative motion between part and abrasive material (A) gives polishing action. Moving part through abrasive mix at a fast tub speed, with low spindle speed, (B) produces voids or dead spots. Slowing tub speed and raising spindle speed (C) eliminates dead spots, allows abrasive mix to contact and polish entire exterior of part. Pressure wave set up when abrasive mix passes the part forces mix into bore (D) where relative motion between mix and part produces polishing action. Interior and exterior of rack-pinion nut shown (E) was deburred and polished at tub speed at 275 sfm and spindle speed of 300 rpm.




# Two Drills Perform Three Jobs . . .

**. . . allowing three tools to perform four operations on auto rear-axle housings. Feature is the single feed unit, with compound movement, that drills and deburrs both ends of a hole in one pass before tapping operation.**




This transfer-and-drilling machine can be easily adjusted to drill and tap the vent hole in any location on the axle. Previously, changes in vent-hole location or housing design resulted in expensive retooling. By using a coolant base under the load station, and bridging the gap between this base and the main machine base with five idle stations, the transfer machine is used to flush out chips from previous operations and drilling. The machines are produced by Buhr Machine Tool Co, Ann Arbor, Mich.

**Feed unit . . .**
on which both drill and deburring tool are mounted, moves them rapidly downward for 0.5 inch, then it trips a deceleration valve and moves at constant velocity of 5.69 ipm—the drill-feed rate.

The auxiliary, hydraulic cylinder gives compound movement to deburring spindle. First, as drilling starts (A), cylinder piston causes deburring tool to move downward at 2.8 ipm relative to feed unit (8.49 ipm relative to the part). This rate continues for 0.19 in.

When top of hole is deburred, spring-loaded bit withdraws into holder and the piston plunges it (B) 0.56 in. downward at rate of 20.11 ipm relative to feed unit (25.8 ipm relative to workpiece). But drill continues feeding downward at the slower 5.69 ipm.

When hole is cleared, deburring bit is pushed outward by the spring. Now cylinder reverses direction (C) and moves deburrer upward for 0.25 in. at 11.35 ipm (5.66 ipm relative to the part).

By the time deburring is completed, the drill has broken through next hole. Both drill and deburrer then move upward together at rapid return rate of the feed unit (the deburring bit having again retracted into its holder). After 1-in. upward travel at this rate, the tools are ready for next cycle. Total cycle time: 8 sec.

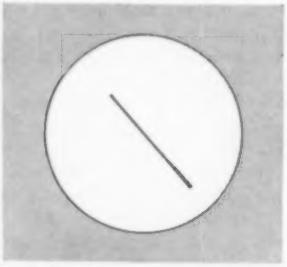
**Typical setup . . .**
shows how vibration sends velocity and force signals to an oscilloscope.

# STRUCTURAL VIBRATION—

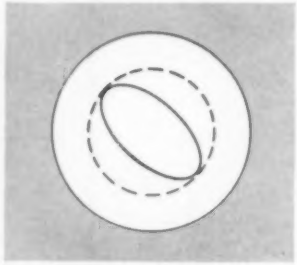
## *an oscilloscope tells the story in pictures*

WILBUR DU BOIS, Boeing Airplane Co, Seattle

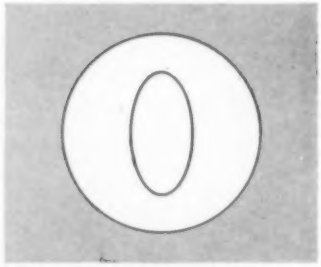
**Here is a quick vibration test for mechanical systems. The 'scope screen shows when resonance occurs, locates trouble spots and indicates what causes them.**



**System resonance . . .**
is indicated on oscilloscope screen by a straight line (which can be considered a closed circle). It shows that velocity is maximum and 180° out of phase with the force—a condition of resonance. Line will appear at harmonics as well as the natural frequency of the system.



**Nonresonant . . .**
frequency causes either a circle or an ellipse to appear. Velocity, and therefore amplitude, are not at a maximum and not in phase with force. Whether the slope is to the left, as above, or to the right, depends merely on how electrical connections to the oscilloscope are made.



**Individual part . . .**
where pickup is mounted is not in resonance here, but some other part of the system, possibly the vibrator-supporting stand, is in resonance. This condition is revealed by an "open circle" pattern in which the vertical coordinate (velocity) is a maximum.

There is a quicker way than lengthy tests to run down trouble in mechanical structures designed to withstand vibrations. Suppose a component hasn't been mounted properly . . . or part of the structure is cracked? The faulty area can be found by vibrating the structure while exploring it with a velocity pickup. Signals from both the pickup and the vibrator are fed to an oscilloscope.

The rest is merely a matter of glancing at a simple picture—the tell-tale line pattern appearing on the 'scope screen—to see how the structure is behaving. Each type of trouble gives its own identifying picture. Besides speed, the method offers accuracy—it works even when natural frequencies and modes are hard to determine, especially when two modes differ by only a few cycles per second.

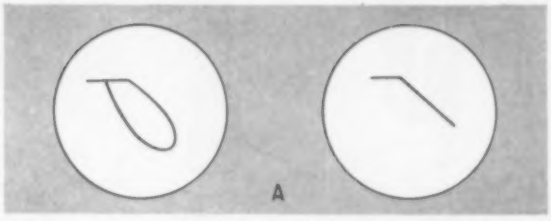
The method is based on the fact that, at a forced resonance of a reasonably homogeneous structure, force input to the structure and velocity response at the forcing point are either in phase or 180° out of phase.

### How It's Done

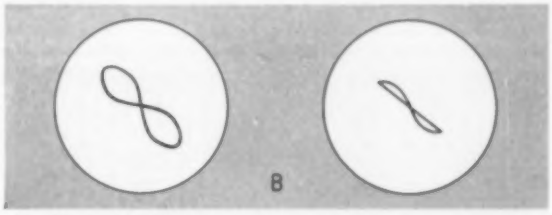
An example of the testing setup is shown atop opposite page. Mount the electromagnetic vibrator and the pickup (it can also be hand-held for probing) on the structure. Place a resistor in series with the winding of the vibrator armature, and feed signals from resistor and pickup to an oscilloscope. (It is assumed that signal from the resistor is proportional to, and in phase with, the armature current.) The force signal is fed to the horizontal channel of the 'scope; the velocity signals to the vertical channel—either directly or through an amplifier with 0° phase shift.

Natural frequencies found this way are accurate within 1%. For mode shapes of various members plot pickup outputs against positions on member at which readings were taken. A millivoltmeter will give pickup output.

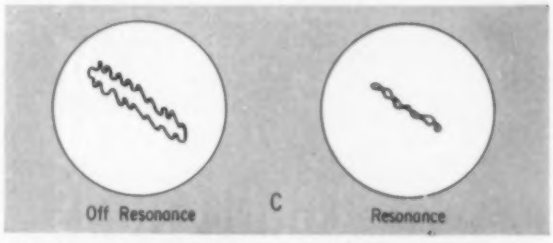
## Watch For These Trouble Patterns Too




*Pickup or vibrator bottoming (vibrator armature hitting the stops, or velocity coil hitting pickup frame)*



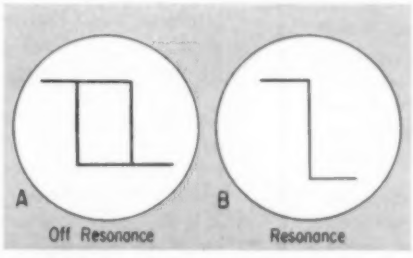

*Vibrating at ½ natural frequency*



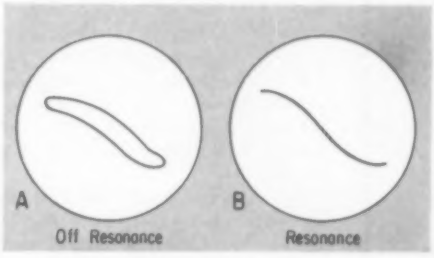

*High frequency superimposed on the fundamental frequency—shows rattling of loose parts*

**Weird patterns above . . .**
will usually appear until slop is removed from system, loose parts secured, vibrator is properly anchored and pickup properly placed.

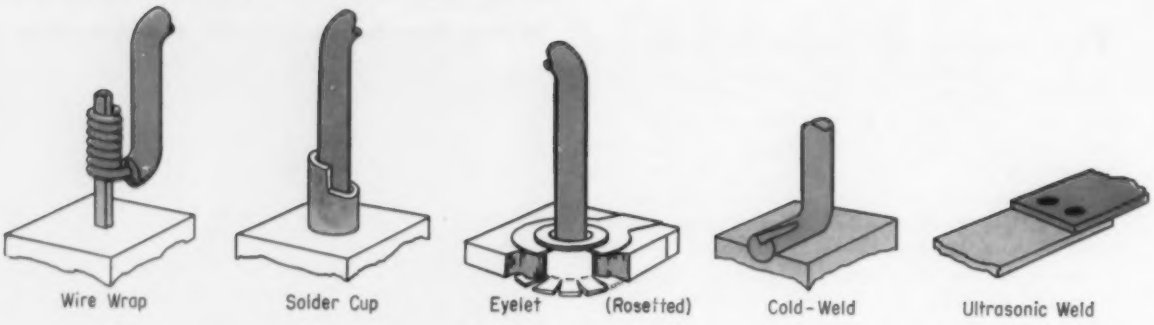
**Cracked member . . .**
may be indicated by pattern that shows large velocity response at one end of a force stroke, but not at the other end. Reason: the crack opens when cracked side of member is in tension, closes when side is under compression.




**Bearing slop . . .**
or free play such as loose joints in a stiff system, will look like either (A) or (B) on 'scope. Natural frequency is indeterminate and the peak-response frequency is indeterminate because the peak-response frequency varies with applied force. *A* is perhaps the worst case of a nonlinear system—almost the entire velocity-response is in the free travel region. *B* shows less severe nonlinearity.




**Armature rubbing . . .**
against something—such restraints cause these patterns. In such nonlinear systems variations up to 30% in apparent natural frequency may occur. If nonlinearity cannot be corrected, different mounts of force should be tried and the resonant frequencies recorded. These may help indicate a more accurate value.




# INDUSTRY'S OPINION ON THE RELIABILITY OF ELECTRICAL CONNECTIONS

*Soldering is often maligned—for certain electrical connections there is no better joint than properly applied solder. Here's a consensus of candid comments on soldering, crimping, welding, clamping, wrapping and other ways to join electrical connectors.*

FRANKLIN D. YEAPLE, *Associate Editor*

**ARTICLE BASED ON EIA TALKS**

Here's the on-the-spot report of an unusual meeting . . . more than 30 technical papers were discussed, but none were read. It was the third Annual EIA (Electronic Industries Association) Conference on Reliable Electrical Connections, held in Dallas, Tex, last Dec 2-4.

This report is based mainly on floor discussion about the basic papers—these had been published in book form before the meeting (see "New Books" in this issue). The opinions here are from an assembly of over 350 engineers, executives and quality-control experts concerned with electrical connections. They represented at least 150 manufacturers, users, and governmental inspection agencies.

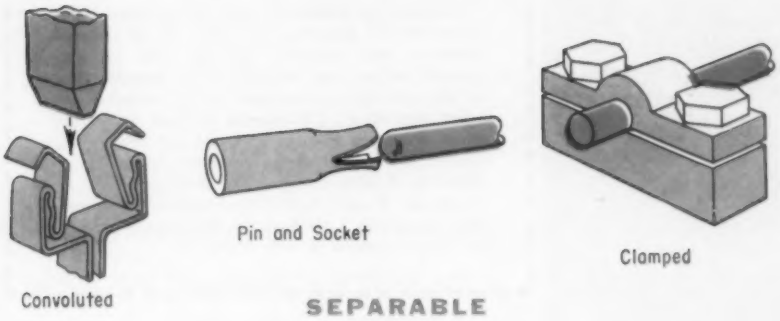
There is good reason for industry's growing interest in reliability of electrical connections. One unreliable connection is bad enough. But when there are many, as in a typical electrical system, the trouble potential mounts astronomically. This shows up when reliability is expressed in percentage—the number of chances out of a hundred tries that a given product will do its job properly.

For example, if a product has 100 parts essential to over-all operation, and each is 99% reliable, the assembly will work an average of only 36.6 times out of 100. And with 10,000 parts—each 99% reliable—the assembly has less than three chances out of $10^{43}$ to work correctly.

If the assembly is electrical, reliability depends heavily upon the connections because there are relatively so many. A typical system (*PE*—Oct 27 '58, p 22) with 3 motors and 11 switches has 400 fixed resistors, which seems a lot. But it has 101 removable connections and 1000 soldered connections. Though these compare favorably with potentiometers, relays and resistors in reliability, they still need much improvement.

## WHY POOR CONNECTIONS?

Main purpose of the connector is to join two conductors and carry the required current reliably without adding excessive resistance or capacitance to the circuit.




It must also be mechanically strong, resistant to chemical action, and easy to fabricate.

**Junction electrical resistance** can be classified in general terms. A "good" value (needed for low-voltage circuits) might be 0.01 ohms or less. Ordinary circuits can tolerate up to 0.1 ohms; a "poor" connection may have greater than 100 ohms resistance. One fact is not always remembered: some solders have 20 times the resistance of copper.

**Deterioration** of contact materials at the conducting point, causing unpredictable resistance changes, may hurt operation more than an initially poor junction will. Deterioration can be chemical (sulphur oxides from burned fuels are troublesome in industrial areas) or it can come from mechanical action such as galling and peening.

### PERMANENT CONNECTORS

The reliability of many permanent-type connections, particularly soldered ones, cannot be checked by test without destroying the connection. Resistance of dry circuits (microv to milliv potential) is difficult to measure accurately. Crimped connections can at least be physically measured to determine percentage of compression—a good indication of contact effectiveness. Some users take double precautions: crimp and solder; wrap-with-wire and solder; or weld and crimp.

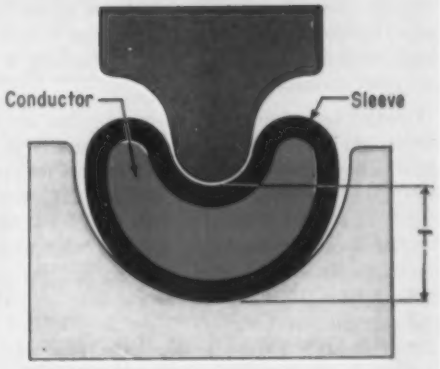
**WireWrap** (Keller Tool Co) is being accepted in many applications, but some companies are waiting for more proof before taking the jump. They question claims that bare wire wrapped around a bare terminal can exert sufficient contact pressure (about 100,000 psi) to achieve strong, permanent metal-to-metal contact—with solid-state diffusion.

**Welding**, if done at high temperature, can cause embrittlement of contact materials. Cold-welding overcomes this disadvantage but requires high pressure to weld the junction. Ultrasonic welding (vibrator energy generates heat at the joint) has not been adapted to printed circuits, but ribbon-type transformer connections are being made this way.

**Soldering** is the most widely used method for making small permanent electrical connections. Although sometimes considered unreliable, it is often the best method

RELIABILITY OF AN ASSEMBLY, %
(Equals $P^n$, where P is part reliability, n is number of parts)

| Reliability of Each Part, % | Total Parts | | | |
|---|---|---|---|---|
| | 100 | 1,000 | 10,000 | 100,000 |
| 99 | 36.6 | ← Less Than 1.0 | | |
| 99.9 | 90.5 | 36.7 | | |
| 99.99 | 99.1 | 90.57 | 37.15 | |
| 99.999 | 99.91 | 99.08 | 91.2 | 39.81 |




**Crimped connection . . .**
**can be physically measured to estimate reliability—dimension *T* indicates extent of compression, therefore contact pressure.**

(CONTINUED ON NEXT PAGE)

for the job if both design and workmanship are handled with care. Here are some ways to get the most out of soldered connections.

One company that uses AN-type connectors melts the solder inside each pin-terminal sleeve by touching a spot-welding probe against the sleeve. A special control and timing circuit discharges a precise amount of current to quickly give the correct temperature (about 100 F above solder melting point). Another company uses ultrasonic cleaning during soldering to wet the metal with solder—no flux needed. Thin gold plating (0.0001 in.) will improve solderability of some copper-based materials.

Soldered connections to through-holes in printed-circuit boards have aroused much discussion. Eyelets are popular, but flange designs vary from simple flares to 8-point rosettes. Biggest problem seems to be keeping solder from breaking away under lip of the flange—a casting problem. Some companies choose to attach the wire leads directly to plated-through holes . . . allowing approximately 0.003 to 0.006 diametral clearance for solder.

Tensile strength of solder is poor. A typical soldered joint is in reality a lead-tin casting made under conditions unacceptable to any foundryman. Stress cracking and grain growth are speeded up in service by vibration and by continuous tensile loadings. Even though the tensile strength of solder can be 6000 psi, a joint may be unreliable if continuous load is higher than 200-400 psi. Aging can improve bending strength, according to one report.

## SEPARABLE CONNECTIONS

Some contact pressure is needed to achieve and maintain metal-to-metal contact in separable connections. Contact design must consider not only configuration of parts, but also the base metals, platings and coatings.

**Contact area** will not be useful, particularly for low-voltage circuits, if oxides, nonconducting films, dirt, or even air spaces increase the resistance above that specified. However, moderate voltages (over 5 v) will sometimes break down this resistive film, resulting in a reasonably good connection.

**Contact force** can be as low as 30 grams for the noble metals, but silver may give poor performance at low voltage if silver sulphide is allowed to form between the contacts. Higher contact forces can help break down the film . . . and once a metal-to-metal contact is established, the forces can be drastically reduced without increasing junction resistance. Nickel, brass or nickel-silver require loadings from 300 to 1000 gm for "dry" circuits (negligible current), and about 100 gm if at least 1 milliamp current is kept flowing through the junction.

**Contact pressures** at insertion, acting on areas as small as 0.004 sq in., can reach 90,000 psi if the connector is not designed properly. Result is to reduce life, measured in number of insertions. Gold-on-gold contacts require only 4000 psi . . . burnishing occurs and 10,000 insertions are possible.

**The insertion force** of a separable connector can be as low as 1 oz per pin and still make good contact. Forces over 3 lb are likely to cause galling. Mineral lubricants with good electrical properties are available. Graphite, however, has poor conductivity, and absorbs corrosive gases. Both graphite and molybdenum will give discontinuities after repeated insertions. Thin gold plating (0.0002) helps reduce galling.

**Soft gold plating** is generally considered best for signal circuits that need extremely low resistance. Rhodium is not quite as good for signal circuits but has better wearing properties because of its hardness. Nickel silver is very durable, but has poor contact behavior at low voltage because of its protective corrosion film. Porosity of plating can cause gradual failure if the base metal oxidizes through the plating and contaminates the surface.

**Silver migration** is the tendency of silver contact material to be absorbed by certain resins and other insulating materials. This migration, which lowers insulation resistance, is accelerated by an electric field, by high humidity, and by sulphurous gases found in polluted air. Researchers at Stanford institute have reported (*PE—June 16 '58, p 11*) that a small amount of copper added to the silver tends to inhibit the migration.

**Galvanic corrosion** in salty atmosphere will deteriorate some metal combinations, but not damage others. Poor combinations are: aluminum with copper; tin-plated aluminum with copper; aluminum with nickel-plated or silver-plated copper; aluminum with gold-plated copper; and copper with solder-dipped copper.

Combinations resistant to galvanic corrosion include copper with nickel-plated or gold-plated copper; tin-plated copper with aluminum; many (but not all) combinations of plated copper with plated copper.

**PERMANENT OR SEPARABLE?**

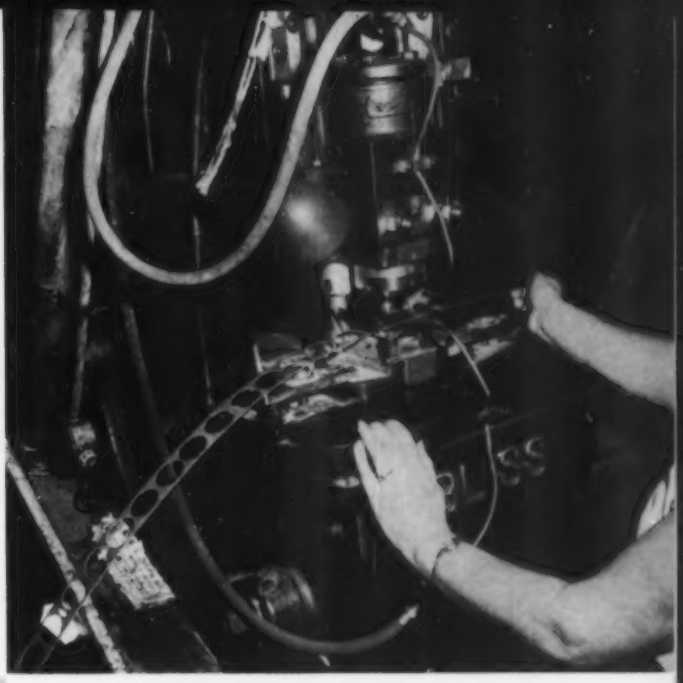
**An electrical connection may be considered permanent if not designed for simple, direct removal. Examples are: soldered, welded (cold or hot), crimped, spliced, and wrapped. The opposite type, called separable, is designed for occasional or frequent removal . . . it includes AN-type, taper pin, spade, threaded terminal post with nut, and spring-loaded connection. Both types can achieve high reliability if properly designed and installed. Although the discussions are listed under "permanent" and "separable," much of the data in accompanying article applies to both types.**

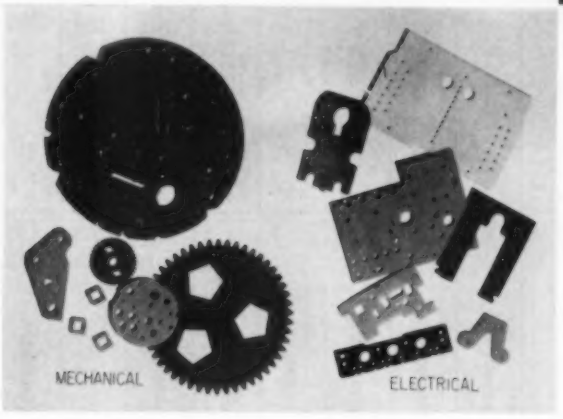
**EDITOR'S NOTE:** An illustrated roundup of most connection types—flexible, screw, strip, wrapped, crimped, soldered, etc—will be found in "Electrical Terminal Connections," Mid-Oct '57, p 1 10.

Several specific types are covered in these articles: "Compression Terminals for Aluminum Conductors," Sep '54, p 160, which describes corrosion-inhibitor compound of metal powder and petrolatum that gives good connection when compressed between aluminum and copper or between aluminum and aluminum; "Multicontact Electrical Connectors," Nov '52, p 184, and "Electrical Connectors for Equipment Power and Control Circuits," June '51, p 117, which give useful construction and performance data on Cannon and Bendix connectors respectively.

A summary of US, British and European literature on 66 different soft solders is presented in "European Solder Developments," June 23 '58, p 97.

**Representative parts made from reinforced laminate, and the punching process, are pictured here. Chart with accompanying article relates punching ease of various laminates with their mechanical and electrical properties. Here's your guide when . . .**






# . . . Selecting PLASTIC LAMINATES for Punching

E C GRAESSER, *Chief Engineer, Quality Control and Applications Engineering, National Vulcanized Fibre Co*

The easiest way is not always the best, and compromise is needed when punching out flat parts from reinforced laminates. A grade of material that is harder to punch—and therefore must be handled hot—may often actually be the best choice because it retains desirable properties to higher temperatures. On the other hand, choice of laminate is also affected by small differences in its punchability. With high-speed punching or die cutting, such differences are often exaggerated and can influence designing the shape of a part. To help find best compromises between high punching rate, price, properties, a comparison guide to materials is given on the next page.

When a suitable material is chosen, laminated parts such as those pictured above can be depended on to be strong, lightweight, resistant to heat and chemicals, and effective insulators against electricity. And because the laminate is easily made from sheets of paper, fabric or mat by automatic methods, cost of the material is relatively low.

Complex parts can be cut from the sheet by either single die or in progressive steps. Complex dies, when single, are harder to make, but by giving all the desired shapes in one operation, they give better registry of the punched pattern. Progressive dies, on the other hand, can be made heavier so they last longer for high-production runs.

## PICKING THE MATERIALS

With possible compromises in mind, selection of laminate should come ahead of designing the part. Selection consists of specifying the sheet thickness and punching grade.

Thickness should be governed mainly by mechanical and electrical requirements. This could be simple but is complicated by the difference in punching ease. The easier punched grades can be handled cold up to $\frac{1}{8}$ in. but the harder grades require heating when thicker than $\frac{1}{32}$ in. If space isn't limited, a thicker laminate of a cheaper cold-punching grade may give savings in over-all costs. However, heavier thickness can bring other complications. As the material becomes harder to punch, the sheared edge becomes rougher, and also slants away from

## COMPARISON OF 32 LAMINATED

| | APPLICATION | ELECTRICAL | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | PROPERTIES (1/16-in. sheet)[1] | XXXP-470 | XXP-209-G | XXXP-455 | XXXP-219-C | G-10-865 | XX-324-P | CE-578-P | LE-675-P | N-1-852 | G-5-813 |
| MECHANICAL | Ease of punching[2] | E | G | G | G | G | F | F | F | F | F |
| | Punching temperature, °F | 73 | 225 | 250 | 225 | 73 | 240 | 85 | 85 | 73 | 73 |
| | Hardness, $R_M$ | 90 | 100 | 113 | 100 | — | 105 | 105 | 105 | 105 | 120 |
| | Flex. strength—longitudinal, psi × $10^3$ | 14.5 | 18 | 28.6 | 20.5 | 72 | 18 | 22 | 18 | 18.5 | 65 |
| | —transverse, psi × $10^3$ | 13.5 | 14 | 21.7 | 15.3 | 63.8 | 14 | 17 | 15 | 15 | 50 |
| ELECTRICAL | Dielec. strength (⊥ to laminate), kv | 1000 | 700 | 1040 | 800 | 810 | 700 | 500 | 500 | 600 | 600 |
| | Dielec. constant (⊥ to laminate), v/mil | 3.8 | 4.5 | 4.27 | 4.1 | 4.80 | 5.3 | 5.3 | 5.3 | 3.3 | 6.8 |
| | Dissipation factor—condition A | .026 | .037 | .026 | .028 | .012 | .040 | .055 | .048 | .024 | .016 |
| | —cond. D 24/23 | .027 | .045 | .027 | .029 | .013 | .046 | .070 | .058 | .030 | .030 |
| | Resistance, cond. C96/35/90, megohms × $10^3$ | 30 | 0.5 | 30 | 20 | — | .06 | — | — | 50 | — |
| | Electrical stability[2] | E | G | E | E | E | G | G | G | E | G |
| | Insulation class, AIEE | A | A | A | A | B | A | A | A | A | B |
| GENERAL | Water absorption in 24 hr, % | 0.48 | 1.3 | 0.37 | 0.50 | 0.09 | 1.3 | 1.3 | 1.3 | 0.3 | 1.0 |
| | Material used for reinforcement | paper | paper | paper | paper | glass fabric | paper | cotton fabric | cotton fabric | nylon fabric | glass fabric |
| | Type of resin | phenolic | phenolic | phenolic | phenolic | epoxy | phenolic | phenolic | phenolic | phenolic | melamine |
| | Comparative price (Grade XX as 1.0) | 1.3 | 1.0 | 1.3 | 1.3 | 3.1 | 1.0 | 1.3 | 1.7 | 3.5 | 2.2 |

[1] Properties also apply to copper-clad laminates

[2] E = excellent, G = good, F = fair, P = poor

the die edge. This means a need for wider dimensional tolerance or, in an extreme case, including a shaving step that will trim the part to size.

Choice of material is guided by the headings across top of the comparison chart. Next important is comparative ease of punching. One reason why cold-punching laminates are preferred is because heating lowers dimensional accuracy. Expansion rates for heated sheet are different between longitudinal and transverse directions.

### DIMENSIONS AND SHAPES

The preferred minimum for hole diameter is one that equals thickness. Diameters can be as low as one-half the sheet thickness when best punching grades are used. Web thickness—that is, minimum dimensions between holes or hole to part edge—is limited to 1½ times the thickness. Square holes, particularly those with sharp corners that build up punching stresses, should be kept at least twice their depth apart to avoid cracking. Staggered holes can be placed somewhat closer.

Radii should be kept larger than $\frac{1}{64}$ in. Sharp, square corners can be had, but only at the expense of a larger corner burr on the side opposite the punch entry. Also, punches with sharp external corners wear faster.

With normal punching practice, tolerances can be kept within ±0.003 in. per in. for cold-punched and ±0.005

## PLASTICS USED FOR PUNCHING

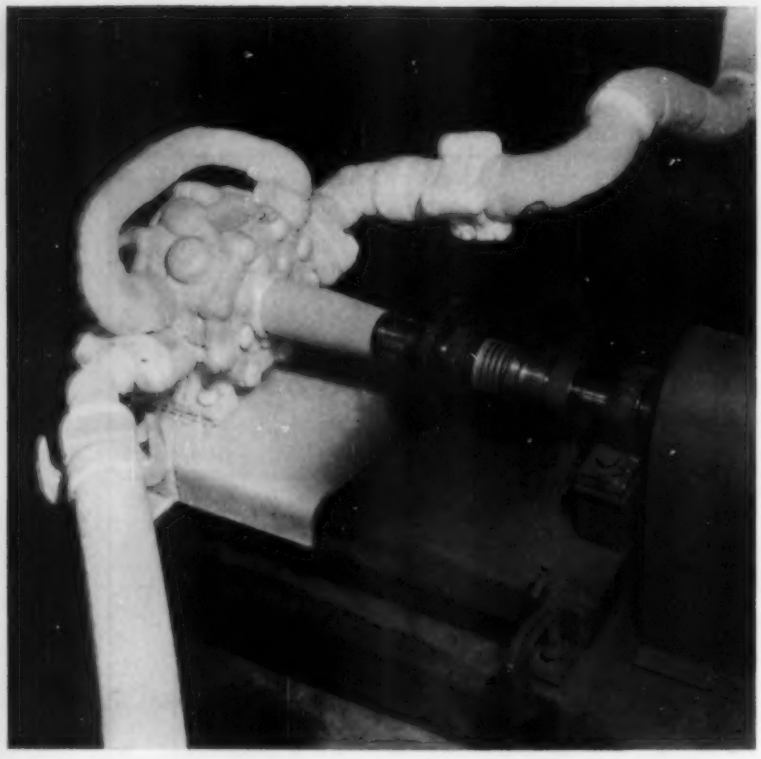
| | | | MECHANICAL | | | | | | | HEAT RESISTANT | | | | | | | | GENERAL PURPOSE | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| G-8-881 | G-11-861 | GP-9202 | L-610-P | E-2040 | C-501-P | K-2100 | X-116-AP | G-3-821 | XN-152 | A-703-P | AA-761-A | AAA-746 | G-1-801 | GH-871 | G-6-833-A | G-7-832 | GP-9204 | P-214-B | PC-208-C | GP-9100-A | GP-9104 |
| F | F | F | E | G | G | G | F | F | F | F | F | F | F | F | F | F | F | E | E | F | F |
| 73 | 73 | 73 | 73 | 275 | 85 | 73 | 225 | 73 | 200 | 125 | 125 | 125 | 73 | 73 | 73 | 73 | 73 | 200 | 73 | 73 | 73 |
| 120 | 115 | 108 | 105 | 117 | 103 | 110 | 110 | 120 | 101 | 111 | 103 | 115 | 110 | 115 | 95 | 100 | 98 | 90 | 70 | 93 | 98 |
| 28 | — | 29.8 | 23 | 30.2 | 22 | 25 | 28 | 32 | 23.7 | 20 | 21 | 36 | 30 | — | 23 | 44 | 31.8 | 15 | — | 23.3 | 20.8 |
| 28 | — | 22 | 18 | 23.1 | 18 | 25 | 23 | 28 | 17 | 18 | 19 | 26 | 20 | — | 19 | 37 | 26.2 | 13 | — | 21.8 | 20.2 |
| 200 | 710 | 700 | — | 1030 | — | — | 700 | 700 | — | 225 | — | — | 250 | 640 | 250 | 400 | 600 | 650 | 600 | 620 | 665 |
| 6.8 | — | 3.97 | — | 4.56 | — | — | — | — | — | — | — | — | 5.2 | — | 4.18 | 3.9 | 4.37 | — | — | 4.35 | 4.78 |
| .02 | .015 | .011 | — | .030 | — | — | — | — | — | — | — | — | .020 | .016 | .002 | .002 | .011 | — | — | .026 | .012 |
| .05 | .015 | .023 | — | .031 | — | — | — | — | — | — | — | — | .040 | .020 | .023 | .015 | .043 | — | — | .087 | .047 |
| 2.5 | 30 | — | — | — | — | — | — | — | — | — | — | — | — | 100 | 0.1 | 4.0 | — | — | — | — | — |
| G | E | G | P | E | P | P | P | F | P | F | P | P | F | E | E | E | G | F | F | G | F |
| B | B | B | A | A | A | A | A | B | A | B | B | B | B | B | H | H | B | A | A | B | B |
| 2.13 | 0.15 | — | 2.0 | 0.42 | — | 2.0 | 4.0 | 1.8 | 1.7 | 1.3 | 2.5 | 1.7 | 1.8 | 0.68 | 0.3 | 0.3 | — | 2.2 | 3.2 | — | — |
| glass mat | glass fabric | glass mat | cotton fabric | paper | cotton fabric | cotton mat | paper | glass fabric | paper | asbestos paper | asbestos fabric | asbestos mat | glass fabric | glass fabric | glass mat | glass fabric | glass mat | paper | paper | glass mat | glass mat |
| melamine | epoxy | polyester | phenolic | phenolic | phenolic | phenolic | phenolic | phenolic | phenolic | phenolic | phenolic | phenolic | phenolic | phenolic | silicone | silicone | polyester | phenolic | phenolic | polyester | polyester |
| 1.7 | 3.2 | 1.6 | 1.7 | 1.0 | 1.3 | 1.3 | .8 | 2.5 | .5 | .9 | 2.6 | 2.0 | 2.4 | 2.9 | 5.8 | 5.8 | 1.2 | .9 | .9 | 1 | .7 |

in. per in. for the hot-punched grades. These tolerances apply to ⅛ in. sheet.

It is best to keep parts as simple as possible. This can be done by avoiding such costly items as very close tolerances, compound curves, smooth edge finish. Often, short-run tooling can be specified for limited quantities up to 5000 pieces.

**EDITOR'S NOTE:** Other articles on sheet plastics and their applications: "Forming Plastic Sheet," Mid-Sept '58, p D4, compares different methods of thermoforming plastic sheet materials, their tooling and costs; "How to Design Out Cost of Plastic Parts," Oct 14 '57, p 77, shows how to spot such costly requirements as heavy walls and extra close tolerances—charts guide selection of basic production processes; "Design Hints for Laminated Parts," Jan '57, p 86, gives best shapes; how reinforced-plastic laminates carry loads best.

A comprehensive study, "Printed Wiring for Industrial Service," Aug '56, p 167 (available as a reprint), covers advantages and limitations of various types of printed wiring. Etched, plated, embossed and pressed wiring are compared. Properties of copper and silver conductors are discussed along with characteristics of phenolic, nylon, melamine, silicone, and epoxy insulating boards. Resistors, capacitors, switches, variable controls, connectors and other components specifically designed for insertion into printed wiring are illustrated and a design roundup is given.



*As more products—like this 2-stage turbine pump—are required for handling supercold gases given by liquefied air, the job of design gets harder: Materials embrittle . . . moving parts "freeze" . . . lubricants congeal. To help understand this new environment, here's an introduction to . . .*

# PRODUCT DESIGN for -300 F

P. E. LOVEDAY, *Division Engineer*
*Linde Co, Div of Union Carbide Corp*

This morning liquid oxygen was delivered to your nearby hospital, stored as a liquid at −297 F, converted to a gas and piped to the patient's bedside. Meanwhile, in industry, liquid nitrogen at −320 F was helping shrink-fit metal engine parts together . . . liquid argon at −302 F was vaporizing to provide inert gas for welding operations. And at Cape Canaveral an Atlas ICBM was being charged with tons of liquid oxygen for another test firing.

Vital to all this work being done by liquefied elements of ordinary air are products designed especially for supercold temperatures—pumps, containers, bearings, seals, meters, and heat exchangers, for example. Let's take a look at some of the basic design problems you'll meet if your product is to operate in this environment—along with some of the solutions.

**Embrittlement** is a problem with all materials, metal or nonmetal, exposed to very low temperatures. The common structural metals like carbon steel and most alloy steels, for example, lose too much ductility to remain useful. However, the austenitic chrome-nickel steels, particularly 18-8 stainless, retain enough ductility for safe service In the wrought condition, many nonferrous metals stay ductile enough too. These include copper, brass, copper-silicon alloys, Monel and aluminum alloys. Most plastics become too brittle at liquid-air temperatures. Exceptions are some of the fluorocarbon plastics like Teflon, Kel-F and fluorothene, which can still take some cold flow. As shown by the impact-strength changes in Table I, materials subject to stress—particularly shock loading—at very low temperatures must be selected carefully. A good reference guide is paragraph UG-84 of the 1956 ASME Unfired Pressure Vessel Code—even though the product may not have to conform to this code.

**Atmospheric moisture** condenses easily on very cold metal surfaces and may freeze up critical moving parts—a safety valve plunger, for example. Two answers, both requiring special design, are possible: Eliminate moisture around the cold part, or raise its temperature so condensation does not occur. Valve design is a good example. Manually operated valves often freeze at the packing, but extending the stem and bonnet will take this critical friction point out of the cold zone.

 REPRINTED—circle E64, inside back cover 

Standard solenoid valves, on the other hand, are widely used in liquid service without stem extension–but the coil and coil housing must be designed to prevent moisture penetration.

**Insulation** is a problem closely related to moisture freeze-up. The air gases are liquefied to make large quantities (in gas equivalent) easy to transport, store, and transfer. But there is a difference of 300 to 500 F between ambient temperature and their boiling points, and this provides a large driving force for heat leak. In addition, these fluids have very low latent heats of vaporization, Table II. This means special design of products to handle them–all paths of heat leak to the liquid must be examined and either eliminated or designed for mimimum heat transfer.

**Conduction** along piping and supports is a common cause of heat leak. But the familiar heat-conduction formula shows ways to reduce this leak: $q = kA\Delta t/L$. Materials with low thermal conductivity $k$ and high strength will reduce the $kA$ product, cutting heat leak $q$. If the material cannot be changed, increasing the length $L$ gets the same result. This approach is the one used in the extended-stem valve, but there the problem is keeping a critical point warm–not preventing heat leak to the liquid, since the low-temperature fluid flows too fast to pick up much heat from the valve.

**Three basic insulating techniques** are used for impeding heat leak to large volumes of liquefied gases–as in storage vessels, portable containers, pump sumps, and pipe lines:

- Closed-cell block insulation like foamed glass and some foamed plastics eliminates moisture penetration and retains original low thermal conductivity for long periods.
- Highly polished surfaces on double-walled vessels cut heat leak by radiation. Evacuation of the gases between the surfaces to $10^{-5}$ mm Hg absolute pressure eliminates heat transfer by conduction and convection. This is the familiar "Dewar" insulation method–expensive and efficient only at these very low pressures.
- Fine powder in a similar double-walled vessel evacuated to 0.01 to 0.1 mm Hg is used to insulate most industrial storage tanks and bulk transport equipment. Even without polished surfaces, such insulation will hold liquid loss by normal evaporation to well within 1% per day. Effect of pressure on vacuum-powder insulation is shown clearly in Table III.

**Shrinkage** of parts chilled to −300 F is substantial and can be critical in massive structures like heat exchangers and piping systems, as well as in moving components like shafts, bearings, gears and threads. With dimensional changes in the order of those in Table IV, special design allowances must be made. By applying these thermal contraction values, room-temperature dimensions of mating parts can be quickly established that will allow ample clearance after immersion. Turbine pumps, long used for these fluids, are a good example. For rigid structures, flexibility should be provided by minimizing anchor points and allowing adequate flexibility between them. Conventional stress-analysis techniques developed for heated structures can be applied.

**Lubricants** commonly used at room temperature will

**Table I—**
**How Metals Embrittle at Low Temperature**

(For 10 x 10 mm keyhole specimens, annealed)

| Metal | Charpy Impact Strength ft-lb | |
|---|---|---|
| | at 70 F | at −320 F |
| 304 Stainless Steel | 85 | 77 |
| 1010 Everdur | 66 | 64 |
| Copper | 47 | 48 |
| 4285 Steel Plate | 26 | 2 |
| A353 Steel (9% Nickel) | 46 | 32 |

**Table II—**
**Basic Properties of Liquified-air Gases**

| | Atmos. Boiling Pt., °F | Temp. Diff., 70 F to B.P. | Latent Heat of Vaporiz., btu/lb | Density, lb/cu ft | |
|---|---|---|---|---|---|
| | | | | Liquid | Gas* |
| Helium | −452 | 522 | 9.9 | 7.8 | 0.0103 |
| Hydrogen | −423 | 493 | 193.0 | 4.4 | 0.0052 |
| Nitrogen | −320 | 390 | 85.7 | 50.4 | 0.0724 |
| Argon | −302 | 372 | 71.8 | 86.8 | 0.1032 |
| Oxygen | −297 | 367 | 91.6 | 71.3 | 0.0827 |

* At 30 in. Hg and 70F

**Table III—**
**Thermal Conductivities of Some Low-temperature Materials**

(Average k-value, 70 to −300 F, btu/hr/sq ft/° F per ft)

| | Material | k |
|---|---|---|
| Insulations | Perlite at atmos. pressure | 0.018 |
| | Perlite at 0.01 mm Hg (abs.) | 0.001 |
| | Foamed-glass and -plastics | 0.015–0.032 |
| Structural Materials | Reinforced Plastics | 0.2 and up |
| | Hastelloy alloy B | 5 |
| | Type 304 stainless | 9 |
| | Aluminum 3003 | 100 |
| | Copper | 220 |

**Table IV—Shrinkage of Metals, in./in.**

(Cooled from RT to −300 F)

| Material | Coefficient |
|---|---|
| Steel | 0.0018 |
| Type 304 stainless | 0.0027 |
| Aluminum | 0.0038 |
| Everdur | 0.0028 |
| Copper | 0.0028 |
| Silver | 0.0035 |

**Lightweight container . . .**
for liquefied gases is this aluminum prototype, shown discharging liquid nitrogen. Weighing 19 lb, the 25-liter vessel uses double-shell vacuum insulation with special insulating material to minimize evaporation loss. Max weight loss due to normal heat leak from the atmosphere is 5% per day for nitrogen.

not retain low viscosity at liquid air temperatures; in addition, organic-based lubricants may create a combustion hazard in the case of liquid oxygen. Fortunately, suitable lubricants—or materials with self-lubricating properties—have been found. Excellent here are dense graphite; fluorocarbon plastics, and fluorocarbon-impregnated porous metals—all being materials that can be shaped easily. Film-forming materials like powdered graphite and molybdenum disulfide provide safe lubrication. The liquids themselves are often sufficient lubrication: Standard stainless steel ball bearings commonly run in nitrogen, argon and oxygen turbine pumps without external lubrication, using plastic retainers to space the balls. For oxygen, the retainer is usually a fluorocarbon plastic like Teflon to eliminate combustion hazard.

## OTHER IMPORTANT EFFECTS

Low-temperature effects aren't the only problem. These liquified gases have other characteristics that influence design of products for handling them:

**Easily vaporized,** these fluids expand in volume 800-900 times when warmed to room temperature at atmospheric pressure. Thus, bottled-up liquids tend to build high pressure, since some heat for vaporization is always flowing to the very-low-temperature area. This means that pressure relief is essential for spaces where liquid can be trapped—as in piping between valves, body cavities of a fully-closed gate valve, and the space between stem and bonnet of any back-seated valve. Common relief devices are safety valves and bursting disks. When specified for safety functions, the same device should not be asked to simultaneously control operating pressure.

**Combustion hazards** arise with only one atmospheric gas—oxygen. Although nonflammable, it supports combustion. In oxygen-rich atmospheres, combustibles ignite easier and burn more rapidly. Oxygen, then, should be kept isolated from combustibles and from ignition sources. This greatly restricts materials choice in design. A good rule is simply to avoid most common organic materials in the places where nonmetals are normally specified—valve packings, gaskets, insulation, seals, cleaning agents, etc. For example, a good packing material is a combination of clean, cotton-free asbestos, shredded lead and graphite powder.

Where the more stable organics like the polyamides, polyethylenes, and fluorocarbons are considered, simulated-use tests should be run. Two other helpful tests, usually run by the purchaser of components for his own satisfaction, are: (1) ignition energy determined from a drop-hammer test, and (2) ignition temperature, found by heating a sample under oxygen pressure in a special bomb. Only after repeated tests on many materials can safe limits be established. For products handling breathing oxygen—aircraft liquid oxygen tanks, for example—materials should be checked for toxicity.

**Asphyxiation hazards** should be checked when the product is being designed for nitrogen and argon—gases which will not sustain life. Release of gas may be hard to prevent completely: A relief valve blows, a hose must be disconnected, or a gasketed joint leaks temporarily. However, safe designs are the ones that allow plenty of ventilation in spaces where spillage is likely to occur.

### SAFETY SUMMARY

Liquefied gases distilled from air can be handled safely if the following four rules are followed in design:

1. Prevent body contact with liquefied gases or with equipment surfaces chilled to liquid air temperatures.
2. Do not confine liquefied gases without adequate pressure relief.
3. Specify only materials suitable for exposure to liquefied gases.
4. Ventilate equipment housings well so concentrations of the gas will not collect.

**REPRINT** of this article can be obtained for your reference file by checking No. E64 on one of the Reader Service cards bound in this issue. For other reprints available see "Current Reprints" listing in this issue on page 96.

**EDITOR'S NOTE:** The influence of temperature on materials behavior is a problem found higher up on the temperature scale too. These three recent articles will help the designer in the elevated temperature range:

"Carpet Plotting," Jan 5 '59, p 60, discusses a new way to display high-temperature materials design data. "Which Coating at High Temperature?" Jan 20 '58, p 61, tells what types are best for corrosion resistance, erosion resistance and compatibility with base metal. "Thermal Stress Fatigue," June '57, p 175, shows how higher operating temperatures may accentuate premature failure in structural parts.

## interchangeable with all standard JIC cylinders

**With the introduction of the ALL NEW T-J Squair Head, Tomkins-Johnson now offers industry the most complete design range of air and hydraulic cylinders. Presently available in bore diameters from 1½ to 8 inches, the T-J Squair Head is an interchangeable cylinder which produces maximum force and efficiency, with minimum pressures . . . and is also adaptable to the use of low pressure oil as the working medium. Write to The Tomkins-Johnson Co., Jackson, Michigan, for Bulletin #SQ 10-58 and complete details.**

***CHECK THESE 10 POINTS OF T-J SUPERIORITY***

1 One Piece Piston

2 Hard Chrome Cylinder Bore and Piston Rods

3 High Tensile Steel Tie-Rods

4 Cushion Adjusting Screw, Externally Adjustable

5 New Super-Cushion for air, or Self-Aligning Master Seal for Oil (T-J Patents)

6 Solid Steel Heads and Mounting Plates Standard all Models

7 Port Design Allows Minimum Pressure Drop on Inlet or Outlet

8 Chevron Type, Self-Adjusting Rod Packing

9 Piloted Packing Gland—Absolute Alignment

10 Piston Rod, Extra Strong—Polished and Chrome Plated for Efficiency and Protection

T-J TOMKINS-JOHNSON

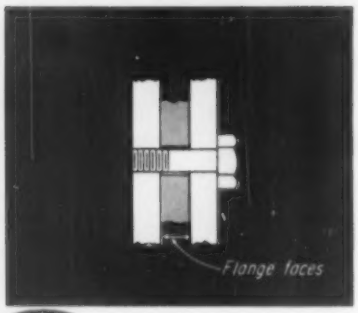
# 12 ways to RETAIN

**Bolts, spacer plates, recesses, welded channels and other arrangements that hold gaskets in place.**

FRANK WILLIAM WOOD JR, *Design Engineer*
*Vitro Laboratories, Silver Spring, Md*

## SOME BASIC METHODS

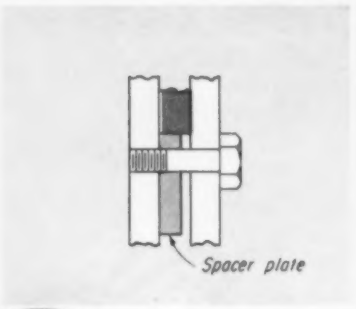
(with advantages in ***boldface italics;*** disadvantages in *light italics*)




**1**

**Bolts through gasket-holes**

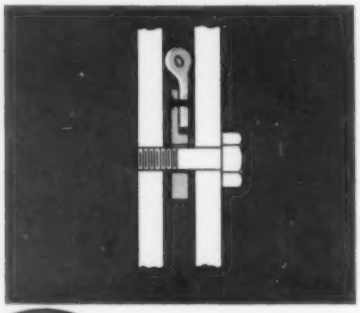
***Simple method—requires no subassembly.***
***Positive location.***
*Parallel alignment of flange faces difficult to obtain.*




**2**

**Spacer plate and adhesive-held gasket**

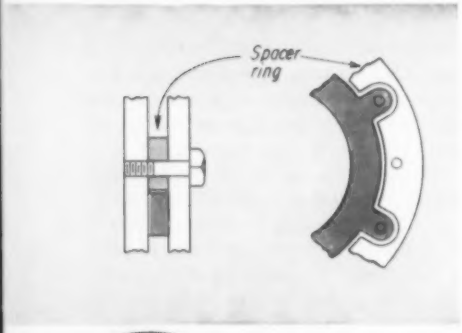
***Permits uniform clamping pressure.***
***Plate ensures parallel alignment.***
***No holes required in gasket.***
*Adhesive application is extra operation.*
*Gasket retention not positive.*



**3**

**Beaded gasket riveted to spacer plate**

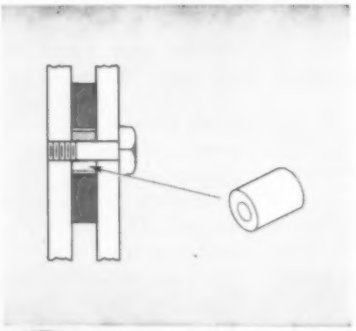
***Positive gasket retention.***
*Extra cost of assembly*




**4**

**Eared gasket and notched spacer plate**

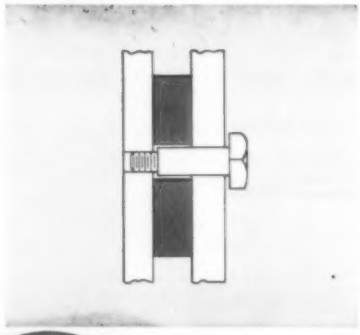
***Positive assembly location.***
***Uniform flange spacing.***
*Parts are more complicated.*



**5**

**Tubular spacer**

***Uniform flange spacing and gasket pressure.***
***Inexpensive part to produce.***
*Requires handling additional parts.*



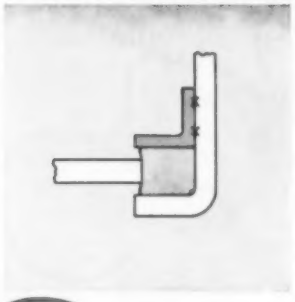
**6**

**Shouldered Bolt**

***Uniform flange spacing and gasket pressure.***

# GASKETS

## SOME MISCELLANEOUS METHODS



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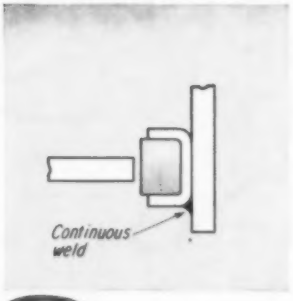


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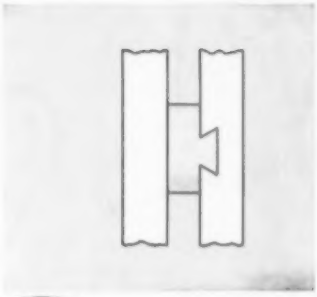

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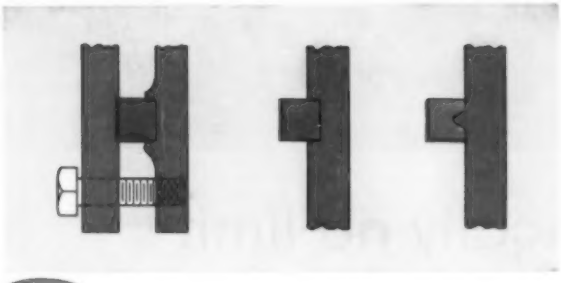
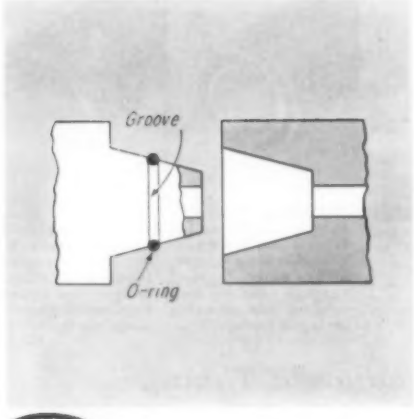


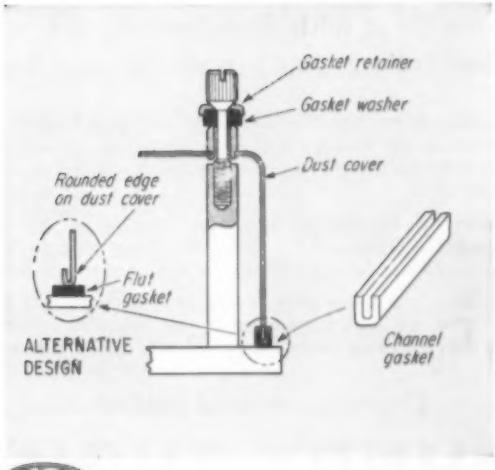
10

7. **Strip gasket** on sheet-metal door is cemented in place between door flange and spot-welded angle.
8. **Sheet-metal channel** holds and locates gasket, which should be cemented in place.
9. **Beveled groove** accommodates beaded gasket, which is pressed into place.
10. **Groove (center) or ridge (at right)** simplify gasket positioning.



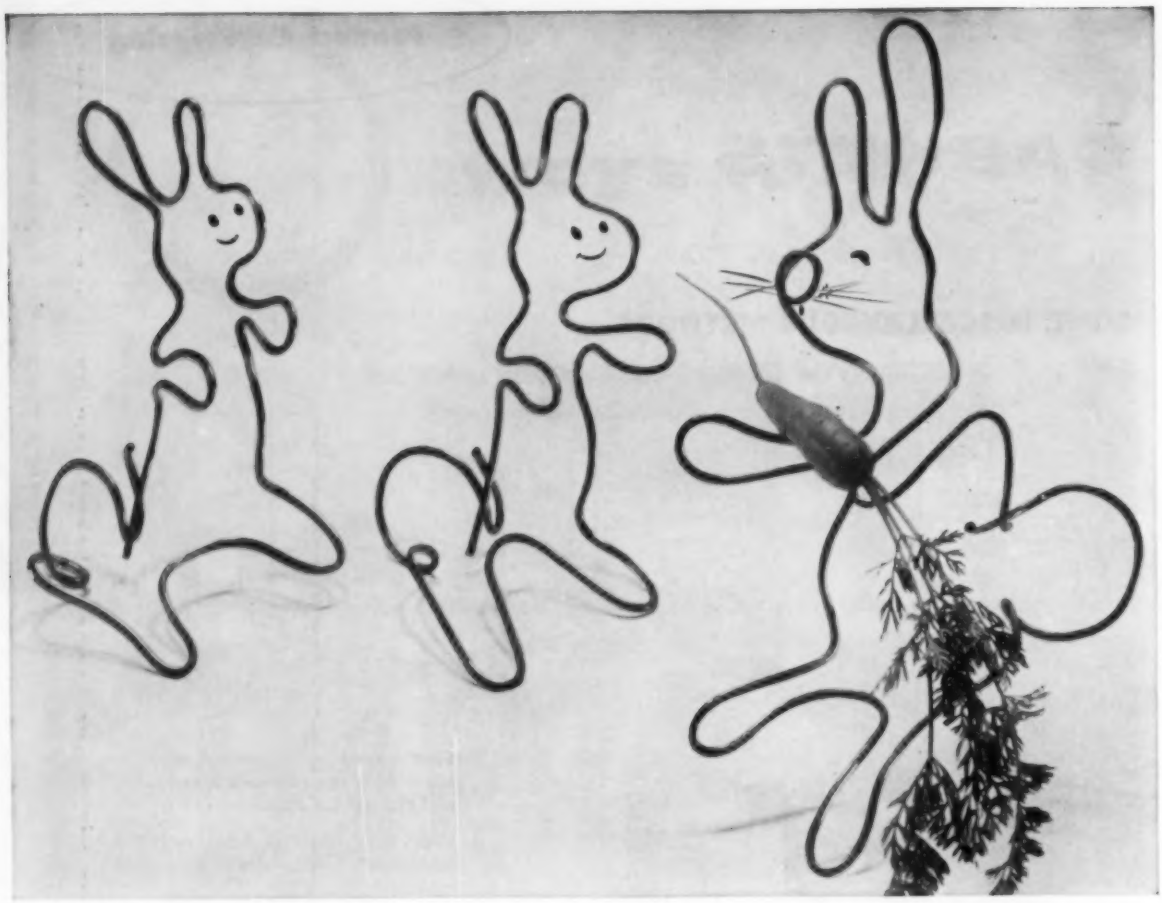

11

**O-ring retention . . .**
and location is easily achieved with a groove having a radius not less than that of the O-ring.




12

**Dust-proof enclosure . . .**
is simple design for which commercial units are available.



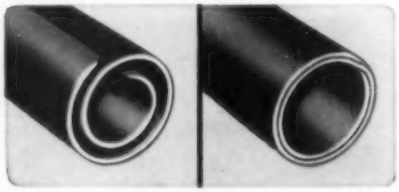
# There's practically no limit to the things Bundy can mass-fabricate

## . . . and we do it with Bundyweld, the stronger, safer steel tubing that's made for easy bending

SKILLED Bundy® technicians turn out many a strange shape—each to its exact tolerances. At Bundy, you get precision *in mass-fabrication.* Jigs, fixtures—even machines—are designed by Bundy specifically to cut customers' unit costs.

**You get Bundyweld® Tubing,** too. An exclusive process (right) gives it unique physical properties. So Bundyweld—master of volatile refrigerants and high-pressure brake fluids—has become the safety standard of two major industries.

Bundy engineers will design your tubing part, or work with you on its development. When we fabricate your parts, you can count on careful packaging, on-time delivery. Bring *your* tubing problem to Bundy. Contact us today!



Bundyweld is the only tubing double-walled from a single copper-plated *steel* strip, metallurgically bonded through 360° of wall contact for amazing strength, versatility.

Bundyweld is lightweight, uniformly smooth, easily fabricated. It's remarkably resistant to vibration fatigue; has unusually high bursting strength. Sizes up to ⅝" O.D.

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WORLD'S LARGEST PRODUCER OF SMALL-DIAMETER TUBING. AFFILIATED PLANTS IN AUSTRALIA, BRAZIL, ENGLAND, FRANCE, GERMANY, AND ITALY

POWER CYLINDERS:

# CHARTS give SAFE PISTON-ROD SIZE

## for strokes of 10 to 300 in. in 5 different mounting styles

Z. J. LANSKY, *Chief Engineer, Hannifin Company, Div of Parker-Hannifin Corporation, Des Plaines, Ill.*

### HOW THE CHARTS WORK

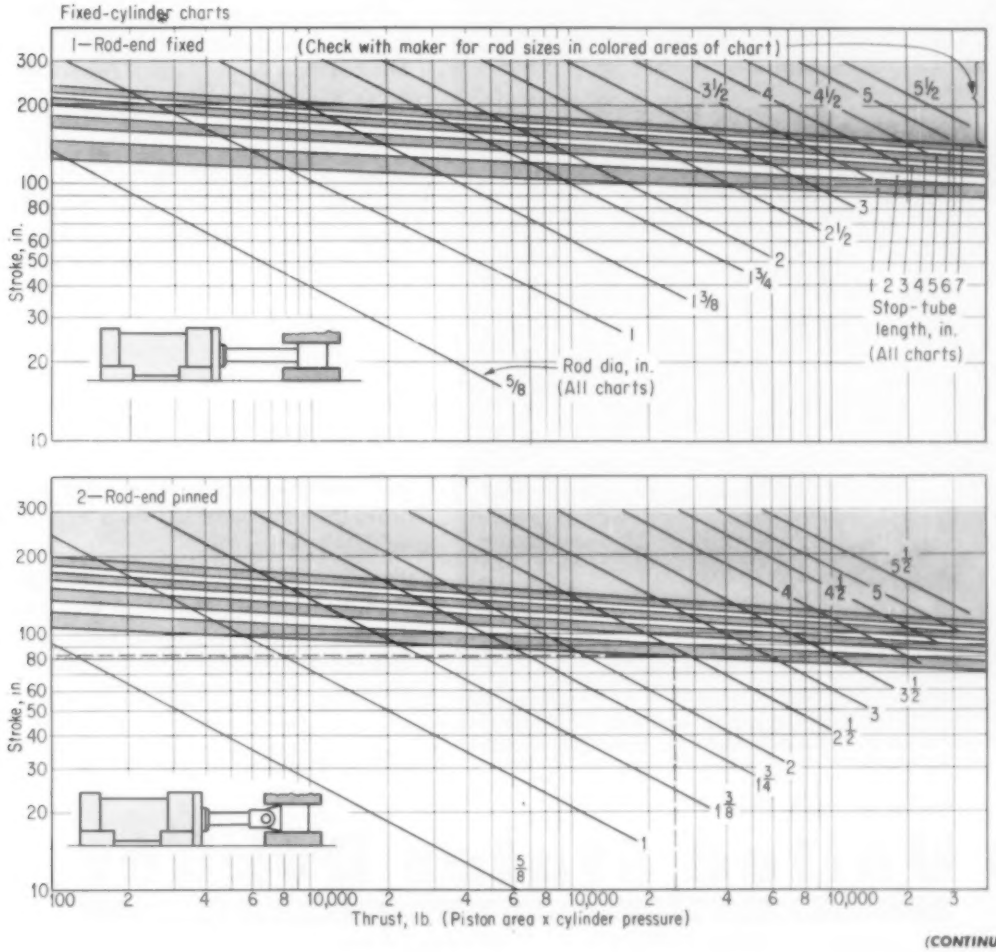
Suppose you want to exert 25,000-lb thrust over an 80-in. stroke, and the cylinder has a fixed-style mounting with a pinned rod-end.

**On chart 2,** appropriate for those mounting conditions, 25,000-lb thrust and 80-in. stroke intersect at a point between the 2- and 2½-in. rod-diameter lines. These lines actually represent maximum safe conditions at which rods will not buckle. Therefore, **always choose rod size to right of thrust-stroke intersecton**—in this case 2½-in. dia.

**Stop-tube** must be used if intersection lies within stop-tube length-bands. In this example a 1-in. stop-tube will be necessary—therefore a cylinder with an 81-in. stroke will be limited to 80-in. stroke.

- For a cylinder pressure of 2000 psi, piston dia works out in this example to be 4 in. **Always reduce pressure if a larger-size cylinder is used without increasing piston-rod dia.**
- Charts are based on 100,000-psi yield-point for rod material, and on standard rod-extensions that are general throughout most of the square-type, power-cylinder industry. For longer extensions, increase the stroke accordingly.

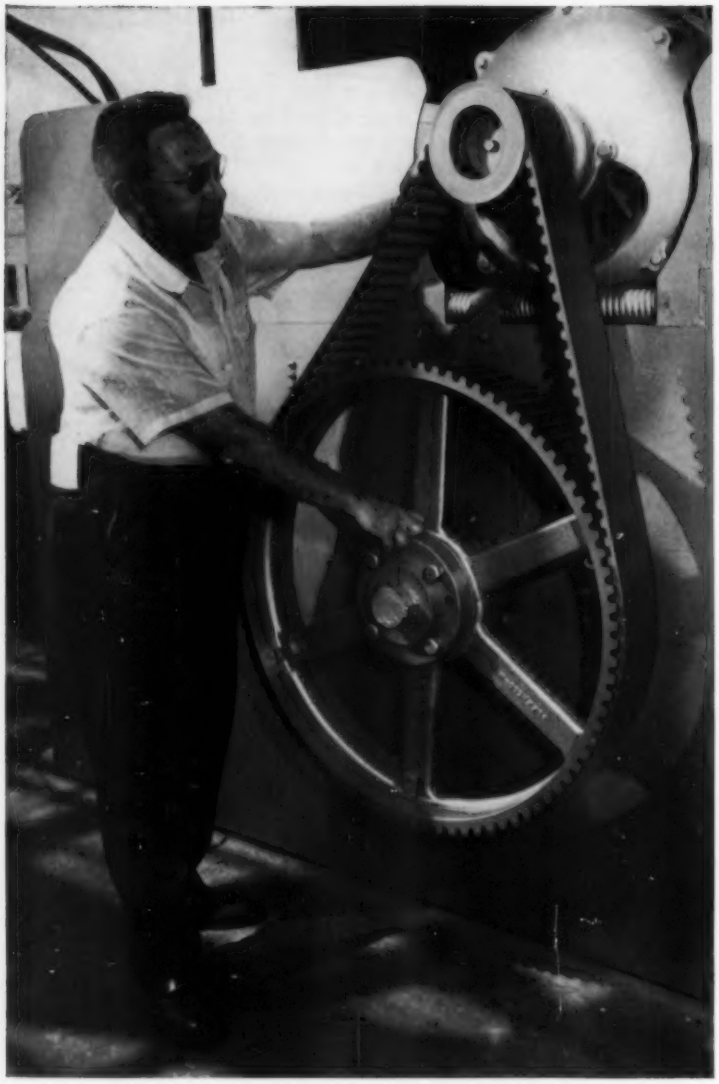
Fixed-cylinder charts




(CONTINUED ON PAGE 69)

US RUBBER **PowerGrip T Belt**

# 9 belts replaced by a single U.S. PowerGrip "Timing" belt



Wire Machinery Co., Chicago, is a specialist in wire drawing and also a maker of wire-drawing machinery. In business for several decades, they began 5 years ago to design U. S. PowerGrip "Timing"® Belt drives into their wire drawing machinery. Their latest example of this use is on a machine in which one 3-inch 1¼" pitch "Timing" belt replaced 9 V-Belts.

"The machine turns out 1500 to 2000 feet of wire per minute," says F. C. Muntwyler, vice president. "PowerGrip brought many improvements. It runs quietly, with no vibration. No lubrication is needed. The belt always retains its permanent center distances — no adjustable centers are needed. This allows us more predictable scheduling of operations and eliminates the need for periodic inspection and adjustment."

U. S. PowerGrip "Timing" Belts are at work on production machines, power tools and appliances in every kind of industry. Their non-slip grip provides close to 100% efficiency. Stock drives are available from U. S. PowerGrip "Timing" Belt Distributors, to convert any drives from fractional to 1000 h.p.

• • •

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**United States Rubber**

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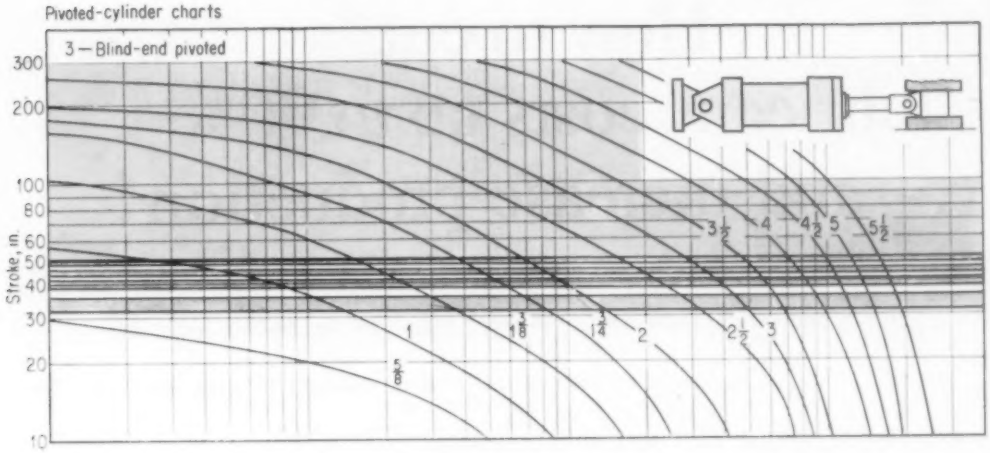
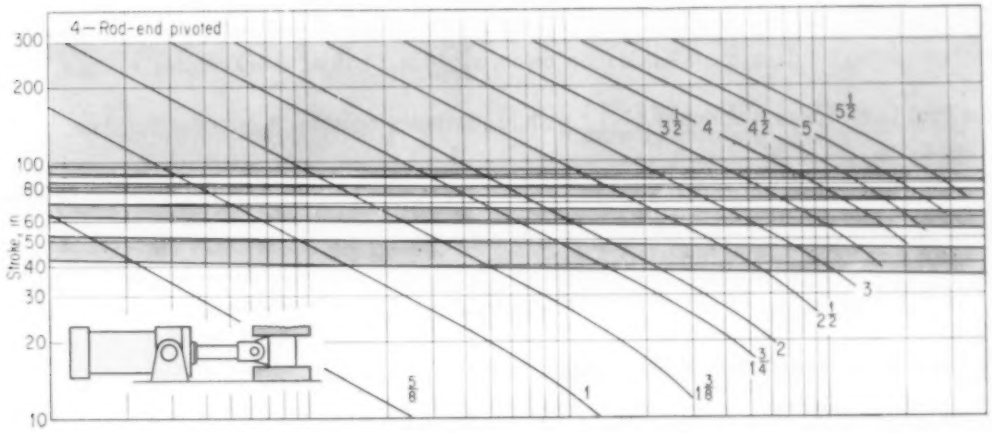
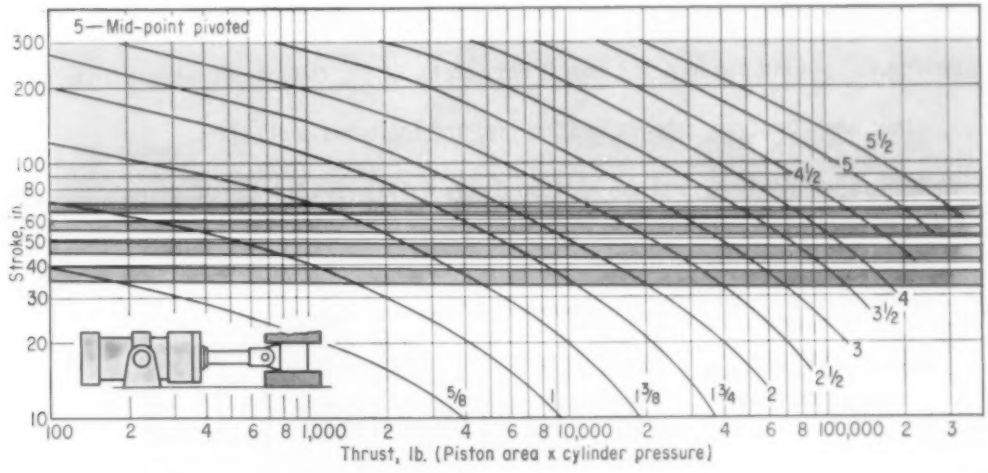
POWER CYLINDERS:

## CHARTS give SAFE PISTON-ROD SIZE (Cont.)

Pivoted-cylinder charts

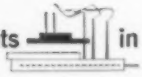


BETTER LUBRICATION BEGINS WITH ALEMITE **OIL-MIST**

# How to cut lubricant costs up to 90% — and increase production!

Large and small plants  in many industries are making important maintenance savings while actually boosting machine output—with Alemite Oil-Mist Automatic Lubrication.

The Oil-Mist system atomizes oil into air-borne particles, carries them through tubing to all lubrication points and bathes every moving surface with a cool film of clean lubricant while machines operate. It provides constant, uniform, completely automatic lubrication to a few or to hundreds of bearings. Accurate and foolproof, Oil-Mist eliminates guesswork. No bearing can be overlooked or over-lubricated.

Three types of Oil-Mist fittings apply lubricant in the form required. Either a mist fitting or a condensing fitting or a spray fitting, is used to lubricate any lubrication point.

An Oil-Mist system can be applied to any new or installed machine. Find out in detail how it cuts costs, reduces man-hours and machine downtime, extends bearing life, and increases production.

Write Alemite, Dept. AA-29, 1850 Diversey Parkway, Chicago 14, Illinois.

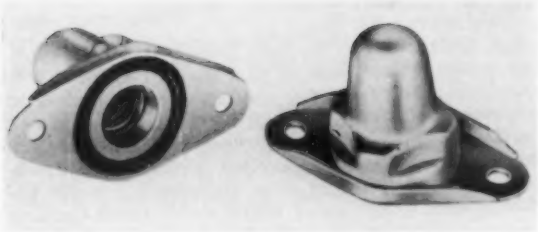
*Makers of these automatic centralized lubrication systems: Oil Mist · Accumatic · Accumite*

**1850 Diversey Parkway, Chicago 14, Illinois**

**ALEMITE** DIVISION **STEWART-WARNER CORPORATION**

Symbol of **SW** Excellence

# SIGNIFICANT COMPONENTS • MATERIALS • PROCESSES



## Self-locking cap nut . . .

assembly consists of a heat-treated drawn steel shell, a rubber sealing ring molded to an aluminum base ring, and a self-locking nut free to float 0.020 in. laterally from a centered position inside the cap to compensate for possible bolt misalignment during assembly. Sealing rings are suitable for sealing of both aromatic and alkylate aircraft fuels per specification MIL-R-6855. Push-out performance is said to exceed specification requirements by 300% and to seal regardless of adverse assembly or jacking action caused by misalignment of bolts. Nut thread height is adaptable to shear thread length bolts at rated tensile loads of 125,000 to 140,000 psi. Available in 10-32 and ¼-28 thread sizes. List prices are $47.80 and $64.80 per 100, respectively. About 90-day delivery. **Elastic Stop Nut Corp of America, 2330 Vauxhall Rd, Union, NJ.**

**Circle 1, Reader Service Card**

## Low-pressure airflow switch . . .

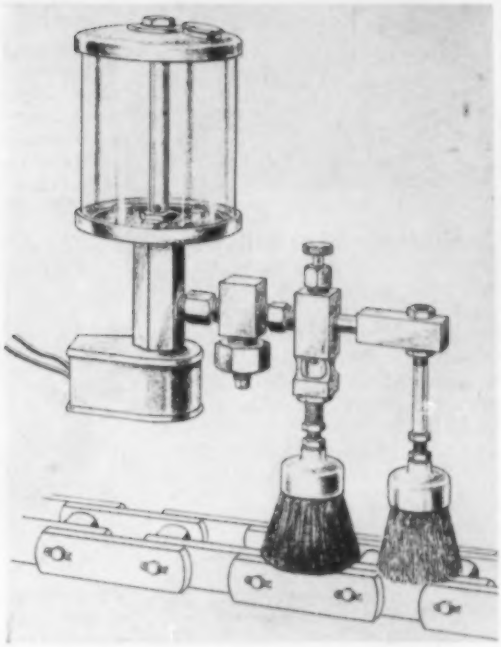
monitors airflow on fan suction or discharge ducts of processing systems. Designed for flat mounting in remote locations or near equipment involved, switch will shut off if anything interferes with desired flow of air from fans. Such interruption causes lead weights to drop switch platform, opening (or closing) circuit. Can also be used to actuate alarms. Standard unit is for pressures of ¼-in. water gage, but units can be built for any suction or pressure to 3 in. water gage. Besides enclosure, main components include diaphragm, mercury switch contactor, lead weights and ¼-in. pipe connection. Rated 5 amp, 115 v or equivalent currents to 230 v. Standard switch, including discount is $18.56, FOB Detroit. From stock. **R C Mahon Co, East 8-Mile Rd, Detroit 34.**

**Circle 2, Reader Service Card**

## Air-line regulator . . .

has built-in pressure-relief valve that allows increases in downstream pressure to bleed harmlessly into atmosphere. Regulator knob adjusts to desired pressure setting by turning on one plane of rotation. Replaceable chrome-plated poppet valve stem may be removed from regulator and new assembly inserted without disturbing air line. Regulators will reduce primary line operating pressures up to 250 psi and will maintain desired downstream pressures of 0 to 50 psi, 0 to 125 psi, 0 to 250 psi, in separate units. Wall or through-panel type mounting brackets, with or without gages, are available. ¼ and ⅜ in. regulators are offered for immediate delivery. Priced at $9.20 each. **Bellows Co, Akron 9.**

**Circle 3, Reader Service Card**



## Chain lubricators . . .

clean and lubricate by feeding oil through mechanically bonded horsehair, nylon or stainless bristles. Offered in ⅜, 1 and 1½ in. dia and ⅜ x 2½ in. widths. Complete chain oilers and cleaners range in price from $30 to $60, depending on size of reservoir and brush. From stock. **Oil-rite Corp, 2382 Waldo Blvd, Manitowoc, Wis.**

**Circle 4, Reader Service Card**

## Conductive PVC . . .

has been undergoing experimental runs to explore theoretical advantages, such as noncorrosive properties, high chemical resistance and ease of extrusion application. This material may prove suitable substitute for copper, aluminum and foil shield. Cost is said to vary widely, according to application. At present, price of conductive PVC covering in a coaxial construction would be about equal to copper shielding. **Phalo Plastics Corp, Shrewsbury, Mass.**

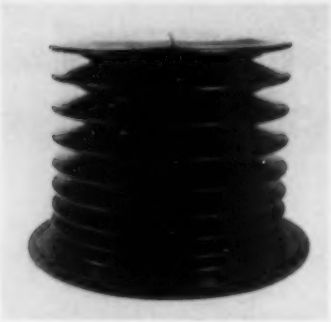
**Circle 5, Reader Service Card**

## Paint for use to 1700 F . . .

without flaking, blistering or burning is offered in aluminum, gold, metallic red and metallic blue. Said to be composed of a clear silicone base with special metal pigment. Combination air-dries to a bright finish in about 30 min. Then, when heated, it is said to virtually fuse with surface to which it has been applied. Paint forms a metal coating said to resist moisture, corrosion, mild acids, alkalis and industrial fumes. Can be applied by brush or spray. Available in quart, gallon and 5-gal. containers; priced at $4.75, $17.95 and $87.50, respectively. From stock. **Chem Industrial Co, 3784 Ridge Rd, Brooklyn 9, Ohio.**

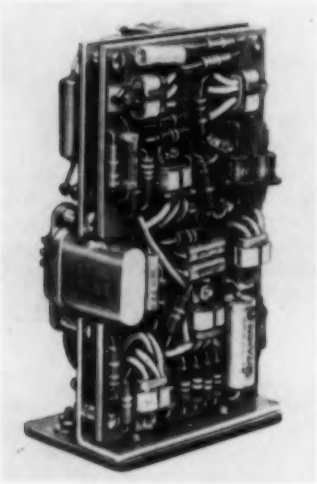
**Circle 6, Reader Service Card**

. . . CONTINUED ON PAGE 72



**Conductive rubber bellows . . .** dissipates high-voltage static discharge to ground and allows uniform tension at different degrees of extension. Where negative pressure is used, rubber is resistant to many organic fluids and to deterioration by ozone and weather. Available various polymers; 2 wk delivery. **Stillman Rubber Co, 8511 Marilyn Ave, Culver City, Calif.**

Circle 7, Reader Service Card

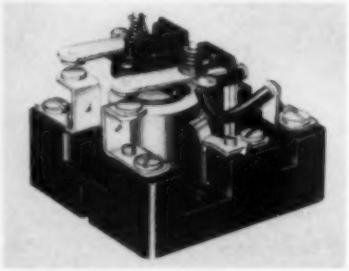


**All-transistor test module . . .** utilizes direct voltage comparison to make programmed measurements with computer speed. Voltage comparator trips a DPDT relay output when unknown signal input exceeds value of known reference input. Has sensitivity of 5 milliv ac, 10 milliv dc; input impedance of 2 megohm min. Operates on power of 115 v, 400 cps, 1 w with relay operating. Output relay contacts are rated 2 amp at 28 v dc. Comparator has repeatabilty of trip point of 1 milliv, overload of 1000 times rated sensitivity and ultilizes printed circuitry and miniature components throughout. Meets or exceeds applicable portions of MIL-E-5400A and MIL-E-5272. Measures 2 $\frac{5}{16}$ x 1 $\frac{13}{16}$ x 4 $\frac{1}{8}$ in. and weighs 12 oz. **Trio Laboratories Inc, Plainview, NY.**

Circle 8, Reader Service Card

**Decorative aluminum alloy . . .** with exaggerated and visible grain structure produced by a specially controlled mill process, developed by Aluminum Co of America, can be anodized and dyed gold as well as other colors. Grain structure is millions of tiny satin and bright facets that create a decorative pattern within metal. Sequined appearance of finished metal offers concealing qualities desirable in decorative applications. Licensing agreement has been completed and alloy is now commercially available. **Croname Inc, Dept PR, 6201 Howard St, Chicago 48 (Niles).**

Circle 9, Reader Service Card



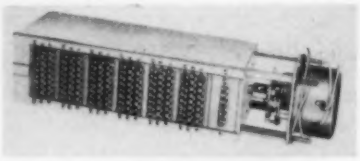
**25-amp power relay . . .** is said to have electrical characteristics equivalent to or greater than those of bulkier devices. Relay has 2PST, normally open contact arrangement. Interchangeable coil assembly can be removed and replaced and contact assemblies can also be rapidly replaced, if necessary, by removing terminal screws. Meets UL specifications. **Guardian Electric Mfg Co, 1621 W Walnut St, Chicago 12.**

Circle 10, Reader Service Card

**Transducers take 2000 F . . .** for periods to 5 min. and operate continuously at 1000 F. Wound on ceramic bobbins, leads are terminated on lugs for secure connections. Lead wires, fish-spline insulated, are supplied up to 3 ft long. Differential transformers are for linear displacement measurements to 0.150 in. and for displacements to 0.5 in. Available now for prototype and model evaluation. **Automatic Timing & Controls Inc, Dept 212, King of Prussia, Penna.**

Circle 11, Reader Service Card

**Solenoid-operated switch . . .** is unidirectional rotary unit consisting of six poles with 24 nonshorting positions per pole. Can be operated at temperatures to 257 F and at altitudes to 80,000 ft. Withstands acceleration of 50 g. Switch measures 2 $\frac{3}{4}$ in. sq x 9 in. over-all depth, including solenoid. Connections can be made from switch body to a phenolic terminal board mounted on side of switch. In field, connections can be made directly to terminal board rather than to switch itself, facilitating addition or subtraction of wires. Unit is completely enclosed in dust cover. Operating life is said to be over 1 million cycles. **Daven Co, Livingston, NJ.**



Circle 12, Reader Service Card

**Pneumatic servovalve . . .** is a 4-way unit for operating pressures from 300 to 1500 psi. Servovalve first and second stages can receive and pass on particles as large as 200 microns without malfunctioning, and first-stage hydraulic preamplifier has only one source of gas—cannot become unbalanced due to gas contamination. High-gain push-pull force feedback servo controls second stage. Hermetically sealed torque motor is isolated from gas. Available with max output port area of 0.01 sq in. each. Standard temperature ranges from —65 to 250 F. Weighs 11 oz. **Raymond Atchley Inc, 2340 Sawtelle Blvd, Los Angeles 64.**

Circle 13, Reader Service Card

**Tissue-thin adhesive sheet . . .** is based on an epoxy resin and can be die-cut to specifications, suiting material to assembly of parts with uniform bonds. It is said to provide a bond exceeding 5000 lb in shear strength and may be used for bonding most materials, such as glass, ceramics or metals. Not affected by temperatures to 400 F. A translucent material, completely flexible, it ranges from 0.0015 to 0.020 in. thick. Material is inserted between components to be bonded and placed in a controlled heat oven. It melts in place at 200 F and is cured for 40 min at 392 F. **Mansol Ceramics Co, 140 Little St, Belleville, NJ.**

Circle 14, Reader Service Card

**Breaker for fhp motors . . .** trips in response to either rising motor temperature or excessive current draw. Automatically shuts off current and then restores motor operation when overload condition is corrected. Actuation by temperature of the thermal element in various applications can be varied to open circuit at any stage of motor temperature or cur-

. . . CONTINUED ON PAGE 74

# Aetna cylindrical ROLLER BEARINGS are

# *VERSATILE*

## ...in assembly
## ...in application

Made in the two basic load carrying types of pure radial and pure thrust, they are supplied with the construction *exactly suited* to your requirements with standard, precision or super-precision tolerances in special alloys to give longer life to your products:

as complete self-contained bearings
with separable inner and outer races
with a full complement of rollers
with retainers of various types and materials

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Each AETNA Roller Bearing incorporates rollers which are expertly ground to a fine finish with a large radius to relieve the high stress points present where two cylindrical bodies are in rolling contact and under load. The crown radius is scientifically determined and varies with the size of the roller. The result is a roller bearing which provides 10% to 15% longer service life by actual service records, because true crowning provides the best distribution of load stresses across the full length of the roller.

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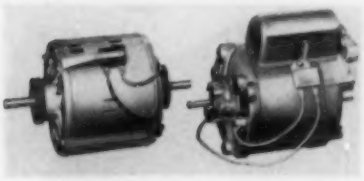
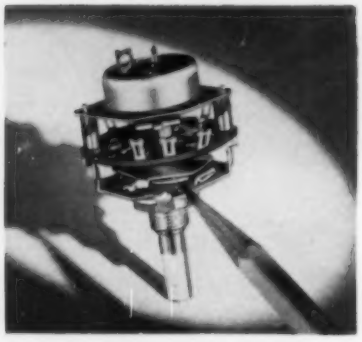


rent rise that may be indicated. Trips as often as overloading conditions recur or short circuits cause instant interruption. Attaches to surface of motor housing with cold-rolled steel box bracket or clamp that goes under the head of one of the motor's through-bolts. **Mechanical Products Inc, Jackson, Mich.**

Circle 15, Reader Service Card



## Spring-return switch . . .

construction eliminates coil spring. Steel alloy spring is built into index mechanism of switch and controls spring return action. Can be supplied as single- or double-section units or as single-section units with line switch. Up to six positions per section, including spring return position, are available. Spring return can be placed in the first or last position. Sections are laminated phenolic type PBE per MIL-P-3115 with voltage breakdown of 1000 v rms. **Centralab, 900 E Keefe Ave, Milwaukee 1.**

Circle 16, Reader Service Card

## Servo assembly . . .

for automatic null balance systems includes a 4-pole, 60-cps servomotor, drive coupling, shaft, bearings and gear drive assembly, digital counters with automatic shutter action to indicate plus or minus digital output, and one or more balance or output potentiometers. Limit stop mechanism is said to eliminate damage to balance potentiometers due to off-scale input signals. Models are available with various full-scale range of counts and speed. For example, a range from −1000 to +1000 counts can be delivered to travel through full-scale in 8 sec or 0.8 sec with readability of 1 digit, without exceeding rated speed of counter mechanism. **Daran Electronics, 1836 Rosecrans Ave, Manhattan Beach, Calif.**

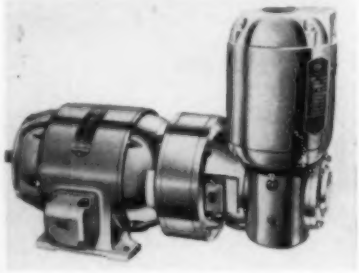
Circle 17, Reader Service Card

Centrifugally cast bronze retainers

## Antifriction bearings . . .

that are self-aligning are said to contain max number of largest dia convex rollers, giving them highest capacity of any spherical roller bearings available. Centrifugally cast bronze retainers are machined to close tolerances. Introduced initially in 1.5748 to 11.0236-in. bore sizes with dynamic load ratings to 288,000 lb, bearings will also be available in pillow blocks in bore sizes of $1\frac{7}{8}$ to 10 in., with a choice of bearing seals. Standard bearings are from stock. **Link-Belt Co, Dept PR, Prudential Plaza, Chicago 1.**

Circle 18, Reader Service Card



## High-, low-speed outputs . . .

with speed-reduction ratios of as much as 100:1 are offered with a new multi-drive package. Consists of a primary motor and a speed reducer, connected by a dc clutch and using a common drive shaft. Primary motor provides high-speed output; reducer provides low-speed output. For installations where operating cycles vary from precise movement to fast speed. Ratings are from $\frac{1}{2}$ through 40 hp. **Reuland Electric Co, Alhambra, Calif.**

Circle 19, Reader Service Card

## High-temperature motor . . .

for continuous-duty speed regulation operates in temperatures of −67 to 251.6 F. The $1\frac{1}{4}$-in. permanent-magnet-governed motor with gear reduction and filter for precise timing applications offers speed that does not deviate more than 3% from 60 rpm with 60 oz-in. load and 24 to 29 v dc supplied under MIL-E-5272 environmental conditions of Procedure I temperature and vibration; Procedure II shock or 10-g acceleration. **John Oster Mfg Co, Avionic Div, 1 Main St, Racine, Wis.**

Circle 20, Reader Service Card

## Low-cost bearings . . .

are said to be suitable for use where precision bearings are now being used but not necessarily required, or where space limitations have previously forced use of plastic or metal powder sleeve bearings. Said to provide ball bearing performance with a specified friction factor of 0.0015 against friction factors up to 8 times as much in many types of sleeve bearings. Speed and load are basically related to material and dimensions. Available in single and double row, some from stock. Included are single row radial and thrust and double row units. **Hartford Steel Ball Co, Hartford, Conn.**

Circle 21, Reader Service Card

## Temperature-stable ceramic transducer element . . .

for equipment subject to drastic temperature variations. Has Curie temperature of 302 F, loss factor of 0.5% and density of 5.5 gm per cc. Frequency constant is 90 kc in. Available in all sizes and shapes required in ultrasonic equipment. Typical applications are in telemetering and airborne sensing circuits, level indicators. **US Sonics Corp, 625 McGrath Highway, Somerville, Mass.**

Circle 22, Reader Service Card

## Size 8 servomotor . . .

for transistor operation is said to have a high torque-to-inertia ratio over an unusually short length. Control phase is designed with high-impedance center-tapped

. . . CONTINUED ON PAGE 76

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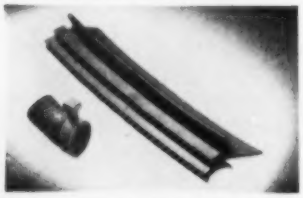

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Calendered and extruded silicone sponge shapes can be covered with heat-resistant fabric.

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winding for transistor use. Servomotor develops 0.33 oz-in. stall torque in standard size-8 frame in length of 1.062. Two-phase winding is for 26 v on fixed phase and a center-tapped 40-v control phase. Power input is 2.7 w per phase at stall and speed is 3500 rpm at max power output. Operating temperature range is −67 to 302 F. Weighs 1.6 oz. **Induction Motors Corp, 570 Main St, Westbury, NY.**

Circle 23, Reader Service Card

### Subminiature relays . . .

for time delays of 1 to 300 sec are for high-altitude, high-vibration and high-temperature applications. Hermetically sealed units are said to exhibit no resonance from 5 to 1000 cps at 10 g, are not damaged by 50-g shock and are fully compensated for temperatures from −85 to 257 F. Thermal relays in heater voltages to 150 v interchangeable on dc or ac of any frequency with a power drain of 4 w SPST, normally open or closed contacts are offered. Are rated 6 amp at 115 v ac or 3 amp at 28 v dc resistive. **Dialtron Corp, 203 Harrison Pl, Brooklyn 37, NY.**

Circle 24, Reader Service Card

### Miniature hex connectors . . .

with 4 to 10 contacts have patented locking ring. Said to be suitable for uniting cables subject to vibration, pulls, or other in-use stresses. **US Components Inc, 454 E 148th St, New York 55.**

Circle 25, Reader Service Card

### Modified short coil relay . . .

of telephone type has bifurcated contact arms with as many as 20 arms per relay (10 per stack). Operates on 100 milliw min per movable arm and can be furnished to operate on voltages up to 110 v dc. Switches up to 4 amp at 115 v, 60 cps, resistive loads. This version is mounted with four tapped No. 4-40 studs on $\frac{3}{8}$ x $\frac{3}{8}$-

(Continued on page 79)

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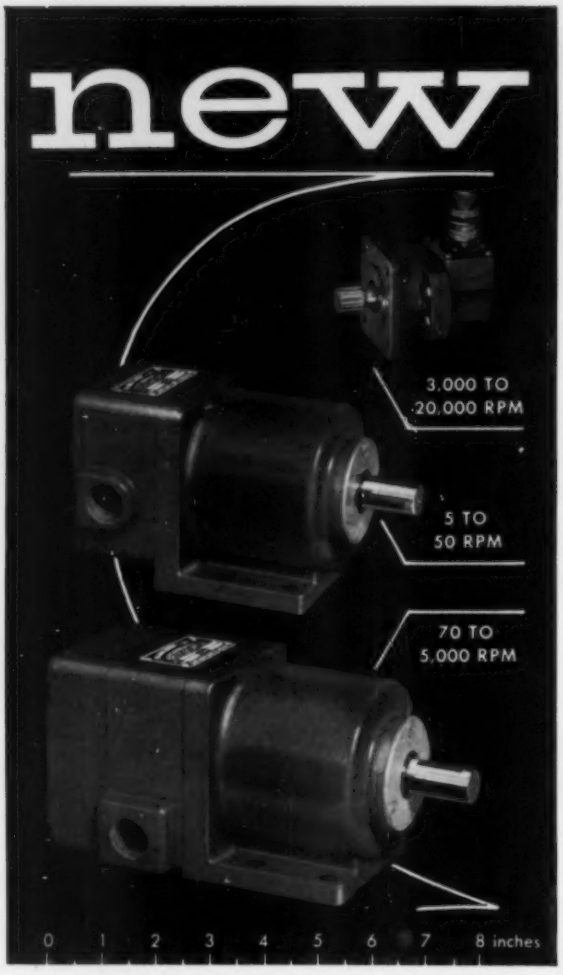


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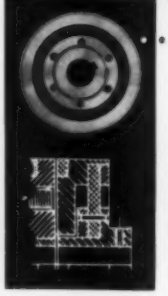

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*Edwin F. Oblinger, Chief Engineer, Parker Sweeper Company, says:*

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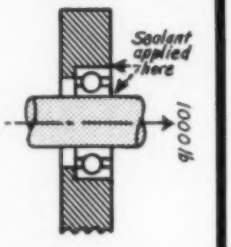
"We used interference fits to prevent bearing races from turning in the gear box of our 4HP Turbosweeper. Maintaining close tolerances was a constant headache. If the fit was loose, the race would slip and fret the surfaces; if the fit was tight, the race would deform and bearing life would be shortened. Then we discovered LOCTITE Liquid Sealant would do away with the need for press fits. We opened up the tolerances for both shaft and housing and used a slip fit, filling the clearance with LOCTITE. The bearings are retained with a force equal to the customary interference fit, but we've reduced rejected parts from 8% to less than 1% and reworked parts fell from 20% to 0! Field reports are excellent."

LIQUID SEALANT ... replaced interference fits and opened up tolerances almost 0.002 in. on shaft and housing for this ball bearing assembly. Load of over 1000 lbs. is needed to break bond.

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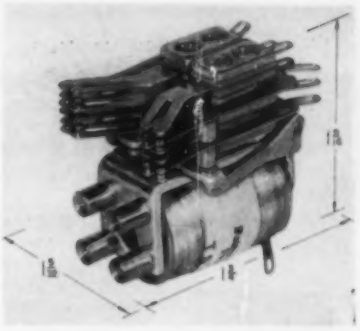
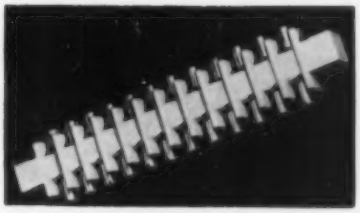


in. centers. Relay measures 1¾ x 1 7/32 x 1 7/16 in. Weighs about 3 oz. **Potter & Brumfield Inc, Princeton, Ind.**

Circle 26, Reader Service Card



### Through terminal block . . .

has connections at top and bottom. Heavy-duty unit comes in several different lengths and number of terminals. Molded of glass-filled alkyd plastic as per MIL-M-14E. Molded-in threaded studs are manganese-bronze. Supplied with slotted brass nuts made to specifications, packaged separately or supplied assembled. Designed by Bureau of Ships and covered by applicable military specifications. **Kulka Electric Corp, 633-643 S Fulton Ave, Mount Vernon, NY.**

Circle 27, Reader Service Card

### Dry bar rubber cement . . .

leaves a thin pressure-sensitive coating when rubbed on a surface and is not sticky to the touch. Paper sticks at fingertip pressure, but may be removed many times. When smoothed down firmly, it forms a waterproof bond said to be stronger than paper itself. Bars are 50¢ each. **Drystik Co, 4356 N Kedvale Ave, Chicago 41.**

Circle 28, Reader Service Card

### Hose assembly . . .

with permanently attached ends includes wire-inserted woven rayon, rayon braid, steel wire single and double braid and steel wire spiral reinforced hose for low, medium and high-pressure hydraulic and pneumatic applications. Perforated cover hose is included. Various types of threaded end fitting connections and adapters are available. Types for heavy-duty operation,

(Continued on page 80)

GENERAL INDUSTRIES

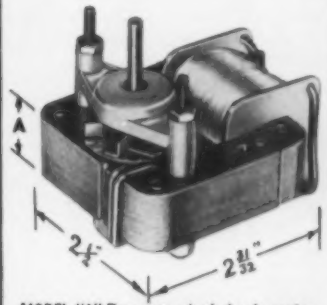
*Smooth Power*

AC MOTORS

1/1550 H.P. to 1/3 H.P.

## PERFORMANCE PROVEN . . . . . .

Specify G.I. to be sure! Nearly half a century of experience in solving the motor problems of large and small motor users throughout the world is your guarantee of satisfaction.




MODEL "A" Two-pole, shaded-pole motor. Proved Dependable millions of times over, it's the power choice of the nation's great-name manufacturers . . . setting an amazing performance record in countless applications from phonographs to kitchen fans to pumps.

| MODEL | HP 2800 RPM | Locked Torque in./oz. | Max. Torque in./oz. | Free Speed RPM | A |
|---|---|---|---|---|---|
| A-3-CW A-3-CCW | 1/500 | 0.7 | 1.1 | 3360 | 3/8" |
| A-4-CW A-4-CCW | 1/350 | 1.0 | 1.4 | 3380 | 1/2" |
| A-5-CW A-5-CCW | 1/180 | 1.7 | 2.7 | 3430 | 5/8" |
| A-6-CW A-6-CCW | 1/130 | 1.9 | 3.3 | 3430 | 3/4" |
| A-7-CW A-7-CCW | 1/100 | 2.1 | 3.8 | 3500 | 7/8" |
| A-8-CW A-8-CCW | 1/90 | 2.5 | 4.5 | 3480 | 1" |
| A-9-CW A-9-CCW | 1/70 | 2.7 | 5.3 | 3520 | 1 1/8" |
| A-12-CW A-12-CCW | 1/60 | 3.0 | 6.5 | 3500 | 1 1/2" |
| A-14-CW A-14-CCW | 1/50 | 3.1 | 7.0 | 3490 | 1 3/4" |
| A-16-CW A-16-CCW | 1/45 | 4.0 | 7.5 | 3490 | 2" |

*Standard shaft diameter .1817, 1/4" shaft available if desired.*

**Motors For All Types of Applications**

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Successor to the Acme screw drive and preferred in many applications to hydraulic and pneumatic systems. Guaranteed 90% efficient in converting rotary twist to linear push (or vice versa). Employs a stream of precision balls and ground lead to eliminate drag and wear in delicate instruments, aircraft, machine tools, massive wind tunnel jacks, etc. For horizontal and vertical actions, indexing, inching and traversing. Consultation and engineering service available. Write for literature.

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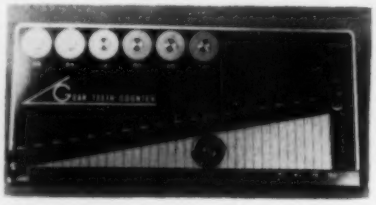
Beaver Precision Products INC.
CLAWSON, MICH.




resistant to shock loads, are said to have been tested at pressures to 7500 psi. Temperature range for most hose is —40 to 275 F. Standard hose ID ranges from ⅞ to 2 in. with pipe threaded ends of ½ through 2 in. **Parker Fittings & Hose Div, Parker-Hannifin Corp, 17325 Euclid Ave, Cleveland 12.**

Circle 29, Reader Service Card



**Gear-teeth counter . . .**
checks diametrical pitch and number of teeth of fine-pitch spur gears. Counter indicates reading directly on vertical scale line to left and tangential to gear. Etched panel in aluminum and black is 11 x 5 in. and weighs 12 oz. Furnished with zipper carrying case. $19.95. **Hayek-Lindholm Associates, PO Box 69, Pleasantville, NY.**

Circle 30, Reader Service Card

**Height-slant control scriber . . .**
can be adjusted to vary heights and angles of templet characters without changing width. Can form verticle or slanting characters at any angle to 45° forward and any height from 60 to 150% of the size of figures represented on drawing templet used. Takes pens from —0000 to —8 and can be used with lettering templets to size —500 C. **Keuffel & Esser Co, Adams and 3rd Sts, Hoboken, NJ.**

Circle 31, Reader Service Card

**Five lettering templets . . .**
have been added to Leroy Line. Included are Spartan Medium, in type sizes from 0.24 to 1.44 in.; Shadow, 0.120 to 0.500 in.; Isometric, 0.100 to 0.200 in., correctly sloped for isometric drawings; electronic tube symbols; standard lettering, for 0.05 in. capitals, vertical or slanting style. **Keuffel & Esser Co, Adams and 3rd Sts, Hoboken, NJ.**

Circle 32, Reader Service Card


# BIG NAME MACHINE TOOL BUILDERS SPECIFY BEAVER BALL SCREWS TO GET OPTIMUM POSITIONING ACCURACY

★ BALDWIN LIMA-HAMILTON
★ CINCINNATI MILLING MACH.
★ CLEEREMAN MACHINE TOOL
★ GALLMEYER & LIVINGSTON
★ GIDDINGS & LEWIS MACHINE TOOL
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★ PRATT & WHITNEY
★ SPRINGFIELD MACHINE
★ SUNDSTRAND MACHINE TOOL
★ THOMPSON GRINDER
★ WARNER & SWASEY

★ PLUS MANY OTHERS

In head slides, etc., where precision control and maximum system stiffness are essentials, engineers turn to ball screws and to Beaver because they specialize in high precision designs.

Can our engineers help you improve your product?

Largest manufacturers of precision ball screws

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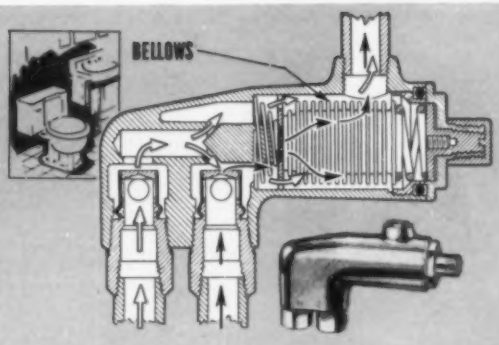
DESIGN FOR

# BEST PERFORMANCE, LOW COST

with **Flexonics** BELLOWS

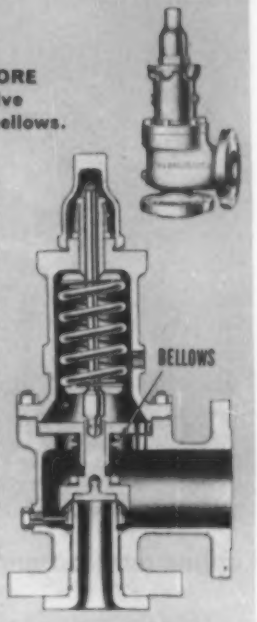



**KOHLER of KOHLER eliminates closet condensation with thermostatic supply valve.**

A Flexonics bronze bellows is the heart of the new Kohler thermostatic valve designed to mix water from the hot and cold lines to deliver tempered water to the closet tank . . . eliminating annoying condensation (sweating). The fast response of the bellows keeps water in perfect temperature balance . . . automatically. Valve requires no adjustment for seasonal variations in water temperature. Another example of the adaptability of Flexonics bellows in designing for best performance at low cost.

**MANNING, MAXWELL & MOORE Consolidated Safety Relief Valve features FLEXONICS sealing bellows.**

After long investigation and literally thousands of tests, a Flexonics stainless steel, two-ply bellows was selected for the Consolidated Safety Relief Valve. The bellows isolates contaminants, corrosion, or viscous fluids from the working parts of the valve. It is designed to allow a maximum variation in back pressure at the valve outlet while at the same time maintaining the important characteristics of high capacity, no change in set pressure, and limited blowdown changes.




For design applications that involve the measurement of pressure or temperature . . . a flexible sealer . . . or even low-torque power transmission – a Flexonics Bellows can be your answer. Send an outline of your bellows application – the Flexonics Application Engineering Staff will be pleased to make recommendations. If you prefer *write for the Flexonics Bellows Design Guide . . . 20 pages of valuable information.*

B-500

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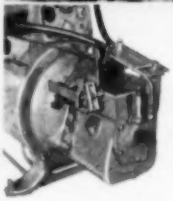

On this Massey-Ferguson Work Bull Multi-Purpose Loader, a FUNK-designed REVERS-O-MATIC DRIVE permits triple operation with one pedal. Instantly changes the speed and direction of travel, leaves hands free for other operations and provides neutral speed control.

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# CATALOGS and BULLETINS

*To obtain copies of literature described below, circle corresponding number on postcard inside back cover.*

**PRESSURE REGULATORS**—Catalog 806, Form 705F, 36 pp. Contains flow and pressure specifications, and inlet and outlet connection dimensions for each unit in line of cylinder, manifold and station pressure regulators. Also describes accessory equipment. Air Reduction Sales Div, Air Reduction Co Inc, 150 E 42nd St, New York 17.

**Circle 33, Reader Service Card**

**STAINLESS STEEL WELDING FITTINGS AND FLANGES**—Catalog TT-600, 54 pp. Revised edition carries dimensional information on fittings and flanges, allowable working pressures, pressure-temperature ratings and corrosion-resistance data. Corrections have been made to reflect recent code changes and to conform with new code interpretations for types 304L and 316L stainless. Applications are discussed. Tube Turns, 224 E Broadway, Louisville 1, Ky.

**Circle 34, Reader Service Card**

**PULSE TRANSFORMERS**—Catalog, 24 pp. Covers brief history of low-level pulse transformers, their measurements, specifications, applications, interchangeability, dielectric ratings, manufacturing and other data. Includes tables, charts and schematics. PCA Electronics Inc, 16799 Schoenborn St, Sepulveda, Calif.

**Circle 35, Reader Service Card**

**INDUSTRIAL ENCLOSED SWITCHES**—Catalog 83C, 20 pp. Gives dimensions, characteristics and operating information on nine housing groups of metal-enclosed switches. 99 listings are shown. Micro Switch, Freeport, Ill.

**Circle 36, Reader Service Card**

**AC MAGNETIC STARTERS**—Booklet EN-150, 14 pp. Describes starters in NEMA sizes 0 through 4 for reversing and nonreversing single-phase and squirrel-cage motors. Also covers component units and elements. Gives starter ratings and dimensions. Cutler-Hammer Inc, 296 N 12th St, Milwaukee 1.

**Circle 37, Reader Service Card**

**DECIMAL-FRACTIONS EQUIVALENTS**—8½ x 11-in. chart printed on coated white card stock with rounded corners. Punched for wall hanging. Decimal equivalents are for fractional units from 1/64 to 1 in. Ohio Seamless Tube Div, Copperweld Steel Co, Shelby, Ohio.

**Circle 38, Reader Service Card**

**PRECISION GEARS**—Bulletin GEA-6430, 20 pp. Descriptions of various gears from less than 1 to over 200 in. dia and with tooth-to-tooth spacing accuracies of 0.0002 in. are supplemented with discussions of design, manufacture, lab control and allied products. General Electric Co, 1 River Rd, Schenectady 5.

**Circle 39, Reader Service Card**

**PRECISION ELECTRICAL SWITCHES**—Catalog, 31 pp. Describes basic switch produced; also heavy-duty, miniature, double-pole, hermetic, one-way impulse and other type. Glossary, price list, general design considerations are also included. Licon Div, Illinois Tool Works, 2501 N Keeler Ave, Chicago 39.

**Circle 40, Reader Service Card**

**CORROSION-RESISTANT ALLOY**—Booklet F-30, 107, 16 pp. Chemical, physical and mechanical properties of alloy C are presented through the use of charts and graphs. Also data on corrosion resistance and high-temperature properties. Haynes Stellite Div, Union Carbide Corp, Kokomo, Ind.

**Circle 41, Reader Service Card**

**ELECTRICAL WIRING DEVICES**—Pocket-size catalog, File No. 31-C-7, 36 pp. Covers 3-wire U-devices, grounding devices, interchange devices, switches, receptacles, combination devices, wall plates, range and dryer receptacles, weatherproof devices, locking devices, fuses, sockets, armored caps and connectors. Eagle Electrical Mfg Co Inc, 23-10 Bridge Plaza S, Long Island City 1, NY.

**Circle 42, Reader Service Card**

**INDICATING DIAL THERMOMETERS**—Catalog 205, 12 pp. Describes redesigned line for temperature measurements in −40 to 1000 F range. Gives specifications for direct and remote reading types and information on filling mediums, case sizes, materials and styles. Tables provide selection and dimensional information. US Gauge Div American Machine & Metals, Inc, Sellersville, Penna.

**Circle 43, Reader Service Card**

**WIRE CLOTH**—Brochure, 12 pp. Specifications and characteristics of coarse to extra-fine meshes are presented in tables and curves. Unique Wire Weaving Co Inc, 762 Ramsey Ave, Hillside, NJ.

**Circle 44, Reader Service Card**

**POROUS FILTERING MATERIALS**—Brochure, 4 pp. Describes industrial filters, including structure, characteristics, efficiency ratings. Gives shapes, sizes available. Curves indicate particle retention, water flow vs pressure for various thicknesses and water flow vs particle retention for ¼-in. thick material at various pressures. Corning Glass Works, Corning, NY.

**Circle 45, Reader Service Card**

**CENTER BONDED MOUNTINGS**—Bulletin 712, 4 pp. Discusses vibration isolation, shock absorption and design, installation, performance and specifications of compression and shear-type mountings. Lord Mfg Co, Erie, Penna.

**Circle 46, Reader Service Card**

**MECHANICAL SEALS**—Catalog section, 4 pp. Contains typical installations, descriptions, data and specifications for seals in sizes for shafts with ¼ to 3 15/16 in. dia. Describes custom line of roll neck seals that provide two-way sealing to keep lubricants in and water out of roll necks. Syntron Co, 240 Lexington Ave, Homer City, Penna.

**Circle 47, Reader Service Card**

**AIR, HYDRAULIC CONTROL VALVES**—Bulletin, 8 pp. Descriptions and specifications for line of manual, electrical, mechanical and pilot-actuated valves, ¼ to 1-in. NPT sizes. Beckett-Harcum Co, 985 W Locust St, Wilmington, Ohio.

**Circle 48, Reader Service Card**

**HIGH-IMPACT REINFORCED MOLDING COMPOUND**—Phamphlet D-203, 6 pp. Advises appropriate molding equipment and mold design for the phenolic compound. Discusses performing, preheating, molding pressures and temperature and cure time for optimum results, as well as physical properties, finishing, machining and shelf life. Durez Plastics Div, Hooker Chemical Corp, North Tonawanda, NY.

**Circle 49, Reader Service Card**

**TEST-POINT CONNECTORS**—Brochure, 6 pp. Gives specifications, outline dimensions and general information on printed circuit connectors available with 1, 6, or 16 test points. DeJur-Amsco Corp, 45-01 Northern Blvd, Long Island City 1, NY.

**Circle 50, Reader Service Card**

**TACHOMETER GENERATORS**—Bulletins, 2 pp each. Descriptions, ratings and mounting dimensions for tachometer indicators. Electro-Mechano Co, Milwaukee.

**Circle 51, Reader Service Card**

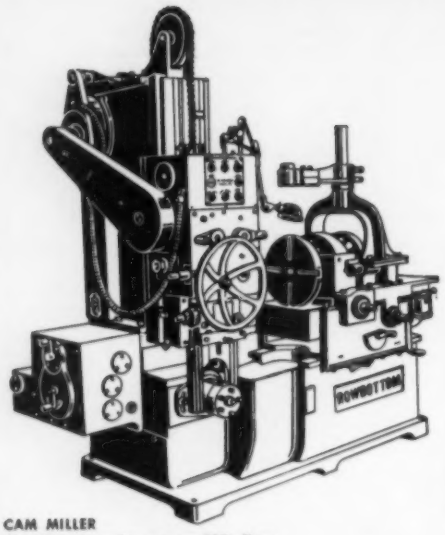
**ELIMINATING PISTON ROD DEFLECTIONS**—Catalog sheet, 1 p. Contains table that gives, in inches, deflections of ordinary commercial piston rods of horizontally mounted cylinders at center of span. Covers 12 rod diameters from ⅝ to 5½ in. dia, indicating danger areas. Discusses methods available for minimizing or eliminating destructive cantilever forces produced by excessive rod sag. Miller Fluid Power Div, Flick Reedy Corp, 2040 N Hawthorne Ave, Melrose Park, Ill.

**Circle 52, Reader Service Card**

**UTILITY PUMPS**—Catalog CP-3489, 8 pp. Presents dimensions, ratings, performance data, materials, construction and application information on pumps that

(Continued on page 85)

# Rowbottom for Cams



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No. 325: Capacity: up to 32" diam.

## *Be sure your "OE" is "OK"*

Original Equipment, (OE), such as *cams*, must be absolutely correct in form and dimension to assure exactness in transmitting the mechanical motions for which they are applied. A great responsibility rests on the maker of the cams. Specifications must be met *exactly* and to the smallest detail from original design to finished product.

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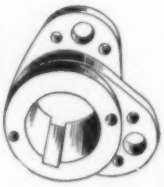
Rowbottom is well equipped to assume this responsibility for cam production either through furnishing Cam Millers and Cam Grinders or in acting as your "Cam Production Department", whichever is most advantageous for you. "Rowbottom" and "Cams" are synonomous.

***Send for illustrated literature showing typical Rowbottom-produced cams and machines for making them. Outline your requirements . . . ask Rowbottom for recommendations.***



*Typical cams produced on Rowbottom machines*

**The ROWBOTTOM MACHINE COMPANY**
30 SHEFFIELD ST.,
WATERBURY CONN.

CIRCLE 139 READER SERVICE CARD

## WAUKEE ROTARY-VANE COMPRESSORS

**with built-in pressure regulator**
**400 to 6000 CFH at 1 to 3 psi**

| CAPACITY TABLE | | | |
|---|---|---|---|
| Model | CFH | Approx. RPM | Motor Size |
| B | 400 | 650 | ⅓ |
| C | 600 | 700 | ½ |
| D | 750 | 850 | ½ |
| H | 1000 | 750 | ½ |
| J | 1250 | 850 | ¾ |
| E | 1500 | 1050 | 1 |
| K | 2000 | 750 | 1 |
| L | 2500 | 900 | 1½ |
| M | 3000 | 1100 | 1½ |
| P | 4000 | 700 | 2 |
| T | 5000 | 850 | 2 |
| V | 6000 | 1000 | 3 |

The Waukee Compressor supplies a steady flow of pulsation-free air or gas mixtures at pressures of 1, 2, or 3 psi. Featuring air cooling, rotary-vane construction, and a built-in automatic by-pass regulator, the Waukee Compressor is smooth, quiet and dependable. Also available for vacuum application.

Whether for OEM or replacement use, the Waukee Compressor provides a neat, sturdy, compact installation. Its rotary-vane design has few moving parts; no metal-to-metal contacts. Ball bearings are permanently lubricated with silicone grease. This simple construction means that any good mechanic can service a Waukee Compressor.

Waukee Compressor: shows rotor and blades; automatic by-pass regulator piston and diaphragm assembly.

*For complete specifications, write for Bulletin 430.*

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**to resist stress, wear and vibration**

**They increase product durability at low initial cost**

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incorporate helical screw principle. Continental Pump Co, 1027 S Vandeventer, St. Louis 10.

Circle 53, Reader Service Card

**PHENOLIC RESIN PRODUCTS**—Booklet CDC-358, 8 pp. Includes production data properties and suggested applications for molding powders, laminating varnishes, foundry resins, coating resins and industrial resins and varnishes. General Electric Co, 1 Plastics Ave, Pittsfield, Mass.

Circle 54, Reader Service Card

**FERROMAGNETIC MATERIALS**—Brochure, 4 pp. Physical and electromagnetic properties of material comprising iron powders dispersed in special binders and insulation to provide cores that operate at temperature to 662 F. Polymer Corp of Penna, Reading, Penna.

Circle 55, Reader Service Card

**INTEGRAL-SHAFT SHEAVES**—Bulletin 20B7897B, 6 pp. Construction and operating features of sheaves for low-cost stepless speed control in large machine drives. Allis-Chalmers, Milwaukee 1.

Circle 56, Reader Service Card

**SATURABLE REACTORS**—Bulletin C-15-S, 4 pp. Describes standard line of proportioning reactors, transductors, switching reactors and preamplifiers. Includes physical and electrical characteristics, dimensional drawings and specifications. Control, Div Magnetics Inc, Butler, Penna.

Circle 57, Reader Service Card

**4-CYLINDER L-HEAD ENGINES**—Bulletins E-128, E-129 and E-130, 2 pp each. Gives basic installation diagrams, power chart and specifications. Engines described are rated, respectively, 46.5 and 49.5 hp at 3200 rpm and 28.4 hp at 4000 rpm. Hercules Motors Corp, Canton, Ohio.

Circle 58, Reader Service Card

**HONING OF PARTS**—Booklet, 16 pp. Gives production rates, size, tolerance, stock removal and finish data on 99 diversified parts from ⅛ to 2¾ in. ID. Sunnen Products Co, 7910 Manchester Ave, St. Louis 17.

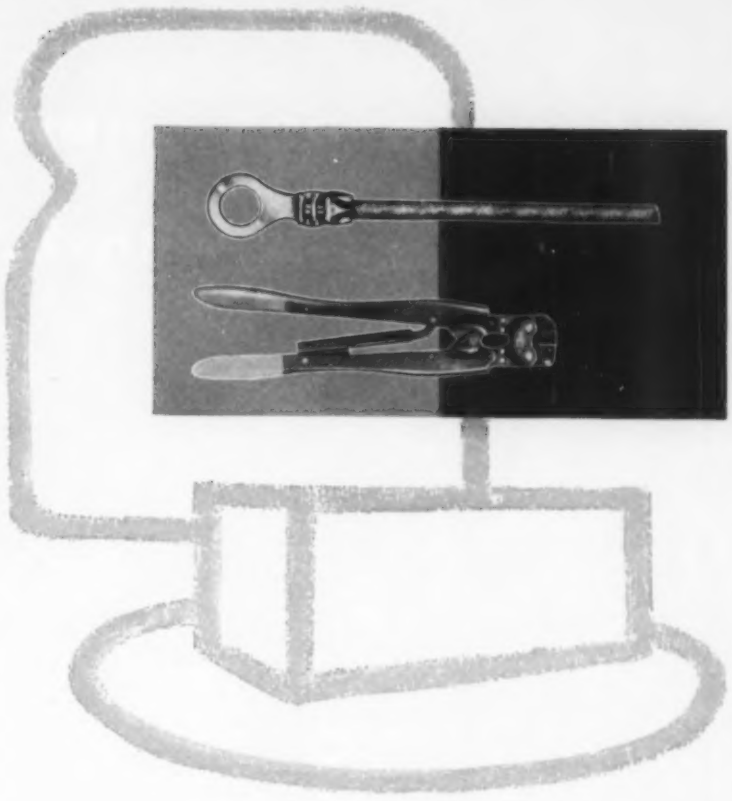
Circle 59, Reader Service Card

**CAPILLARY TUBING**—Data memorandum 11, 11 pp. Defines capillary tubing and discusses materials, tolerances, finishes, special processing and inspection techniques. Chart gives max lengths for combinations of OD and ID. Superior Tube Co, 1556 Germantown Ave, Norristown, Penna.

Circle 60, Reader Service Card

**SELECTING A TIME SWITCH**—Catalog 159, 8 pp. Explains principles of switching and timing; discusses performance characteristics and available switches. Includes typical wiring diagrams and specifications. Sales Dept, Tork Time Controls Inc, Mount Vernon, NY.

Circle 61, Reader Service Card

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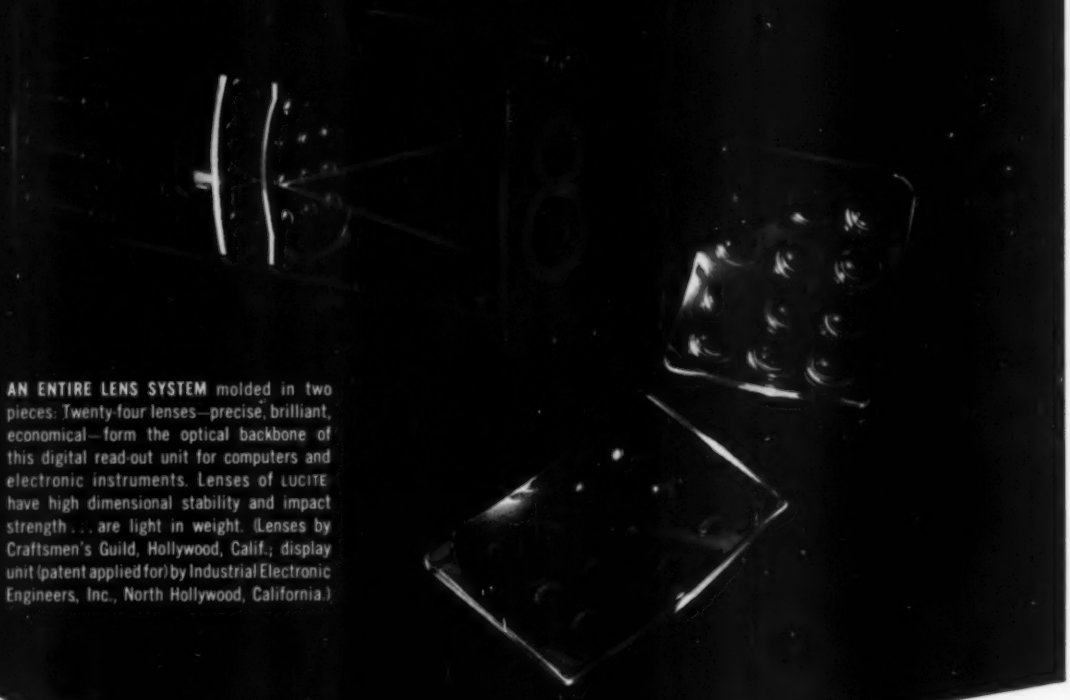

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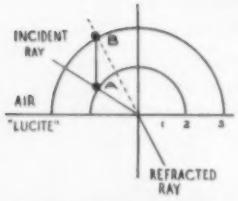


**EASY WAY TO FIND THE ANGLES.** The index of refraction of LUCITE is 1.49. Since this is practically a 1.50/1 or 3/2 ratio, it is easy to construct the path of a light ray through LUCITE. Draw two semicircles as shown, centered at the point of intersection of the incident ray. Draw a perpendicular from point A on the inner circle to point B on the outer circle. The continuation of the line drawn from B through the origin gives the path of the refracted ray.

EVEN if LUCITE did not possess its brilliant transparency, you would want to use it in your designs for its other valuable properties. LUCITE is a strong material—stronger in some respects than plastic materials that are known primarily for high strength. LUCITE is outstanding for resistance to sunlight, weathering and many classes of chemicals. The resin can be economically molded with a high degree of accuracy. With recent developments in LUCITE, the design possibilities are rapidly widening.

**WRITE FOR VALUABLE NEW BOOKLET.** Title: "A New Look at the Product Design Qualifications of a Popular Plastic, LUCITE." See how LUCITE makes possible new uses, greater sales potential. The address: E. I. du Pont de Nemours & Co. (Inc.), Polychemicals Dept., RM. L-36-2-2, Du Pont Bldg., Wilmington 98, Delaware.

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# DESIGN ABSTRACTS

## Subjective Measurements

Stating that "every act of measurement involves a human judgment," differentiations are discussed between what are termed "physical" and "subjective" measurements. Precision of measurement is determined by rating reproducibility capacities of the system used. Whether goal of measuring procedures is engineering or scientific work, established principles for the design of experiments should be applied.

*"Subjective Measures in Engineering," John Versace, Chrysler Corp; SAE paper 2.S, 485 Lexington Ave, New York 17.*

## Oil Consumption in a Diesel

Using radioactive lubricating oil, correlation between break-in wear and oil consumption was attempted. Consumption was also investigated as a function of engine load, speed, temperature, piston-ring configurations.

*"A Study, Using Radioactive Lubricating Oil, of Rate of Oil Consumption in an Operating Diesel Engine," Pobereskin, Sunderman, Fithian, Battelle Memorial Institute and Cooper Bessemer Corp; ASME paper 58-A-143, 29 W 39th St, New York 18.*

## Oxidation of Gear Lubricants

A simple laboratory test for evaluation of oxidation stability of gear lubricants provides results that correlate adequately with field experience.

*"Oxidation of Gear Lubricants—Laboratory and Field," Pohorilla and Hart, Kendall Refining Co; ASTM Bulletin, Dec 1958, 1916 Race St, Philadelphia 3.*

## Simplified Calculation of Design Stresses

Formulas are given for designing machine weldments, covering three factors: load, characteristics of individual member, stress and strain. How to provide resistance to bending and twisting are discussed and illustrated.

*"Simplified Approach to Calculating Design Stresses, O W Blodgett, Lincoln Electric Co; Welding Journal, Dec '58, 33 W 39th St, New York 18.*

## Stress of Threaded Fasteners

The results of a survey of 800 publications conducted by Case Institute of Technology for Industrial Fasteners Institute are described. The study was devoted to nuts and bolts—with the emphasis on nuts. Major classifications used were: load distribution, bolt fracture, thread stripping, nut height and material. Some 30 references are included in this article.

*"Literature Search on Stress Analysis of Threaded Fasteners," Fasteners, Vol 13, No 4, Industrial Fasteners Institute, 1517 Terminal Tower, Cleveland 13.*

## Vibration

Various types of vibration are discussed, including those caused by imbalance, torque, exterior factors (such as ocean waves and paving irregularities), dry friction, oil whip, flutter, obstructions in flow streams, shimmy, unstable combustion. Some theory and math is also included, as well as some calculation techniques.

*"Vibration: A Survey of Industrial Applications," J P den Hartog, MIT; Journal of Society of Naval Engineers, Nov. '58, 1012-14 Street NW, Washington 5, DC.*

## Rapid Loading of Plastics

A comparison of both high and low values of mechanical properties for cellulose acetate, cellulose nitrate, nylon, polysterene, polyethylene and other materials was obtained with test equipment that applied stresses in 5 to 15 millisec. Emphasis is on procedures designed to measure work required to produce yield.

*"How Plastics React Under Rapid Loading," Rugger, McAbee and Chmura, Picatinny (NJ) Arsenal; SPE Journal, Dec. '58, 440 Post Road, Orange, Conn.*

*"It was just a* suggestion, *Finchley!"*

**VIEWER** uses lenses of LUCITE to give distortion-free brilliance and depth to 35-mm. slides. LUCITE was selected for its fine optical quality and high, uniform light transmission. (Manufacturer: Craftsmen's Guild, Hollywood, California.)

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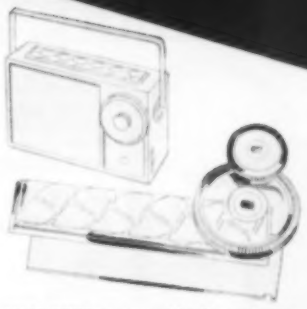

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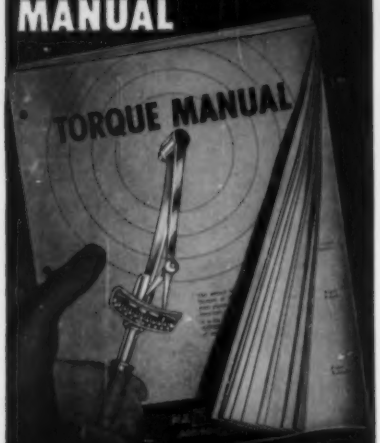


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# NEW BOOKS

## Reliable Electrical Connections–1958

*Third EIA Conference on Reliable Electrical Connections. Published by Engineering Publishers, Div of AC Book Co, Inc; General Post Office, Box 1151, New York 1. 6 x 9, 286 pp. $7.75.*

This conference report was published before the conference–a new concept. (See *PE*—Dec 22, p 27 for summary of meeting.) The report contains 32 illustrated papers by 45 leading engineers and scientists, covering majority of miniature and low-power (less than 10 hp) electrical and electronic connections. Airborne and electronic types are the main ones discussed, although many discussions also apply to industrial. Soldering problems are given lengthy treatment.

Printed-circuit and AN-type connections are analyzed under these topics: vibration; plated-through holes; eyelets; quality control; coaxial plugs; military requirements; sliding contacts; ultrasonic welding; resistance welding; galvanic corrosion; contact coatings; resistance soldering; wire sizes; pigtails; separation forces; and Wire-Wrap. Industrial power connections are treated in these topics: permanent splicing: ultrasonic welding of ribbon-coil transformers (through insulation) compared with capacitor discharge welding; aluminum power connections (to over 100 amps).

## The Solid State for Engineers

*MAURICE J SINNOTT. John Wiley & Sons Inc, 440 Fourth Ave, New York 16. 6½ x 9½, 515 pp plus index. $12.50.*

This book is neither a textbook on engineering materials nor a treatise on solid state physics. Instead it is an attempt to give the engineer the basic principles underlying the behavior of materials. After the opening chapters on the structure of matter and crystallography, the author discusses the application of these phenomena to engineering problems. Chapters on thermal stability, elastic and plastic deformation, electrical and optical properties follow.

The last chapter, "Miscellaneous Surface Phenomena," demonstrates the point of development of the solid

(Continued on page 89)

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state physicist's evergrowing understanding of metals and nonmetals. Dr Sinnott has provided a useful introduction for the product designer to the new aspects which so many of the old familiar engineering materials take on under analysis by the solid state physicist.

## Dictionary of Physics

***Edited by H J GRAY. Longmans, Green & Co Inc, 55 Fifth Ave, New York 3. 544 pp, 6¼ x 10. $16.50.***

The biggest criticism of this book is that its title is far too limiting. It might well have been called "Dictionary of Electrical Engineering," and it contains many mechanical engineering terms as well. Prepared in England, it is surprisingly up to date. For instance, the table of elements includes mention of element 101, mendelevium. Among its useful features are inclusion of a good many men of science (E. O. Lawrence, for instance), and frequent references to sources of definitions—many of them US publications.

## FBI Register—1959

***Kelly's Directories Ltd and Iliffe & Sons Ltd, Dorset House, Stamford St, London S. E. 1. 9½ x 7½, 1,140 pp, approx $7.50.***

This guide to a cross-section of British industry lists products and services of over 7500 member firms of the Federation of British Industries, under more than 5400 alphabetical headings.

In addition to the buyers' guide, there are seven other sections, giving

(Continued on page 91)

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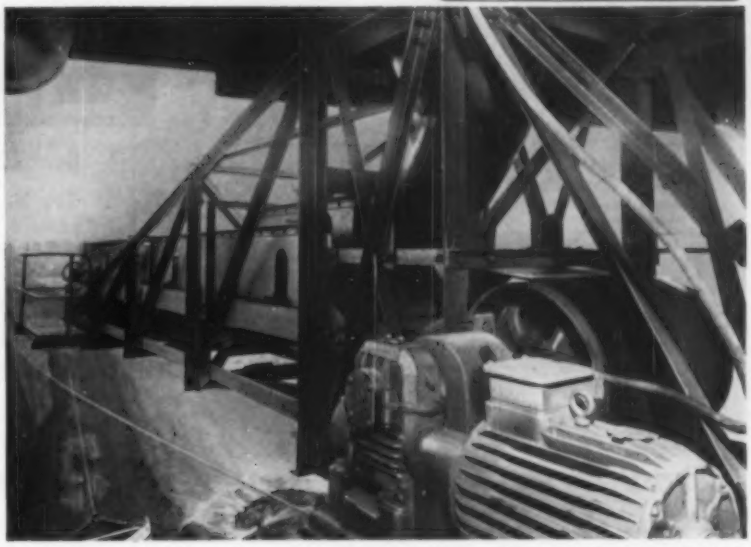

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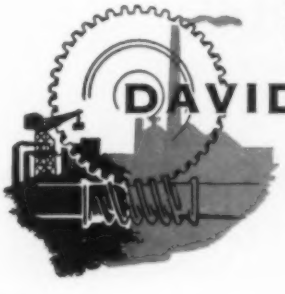

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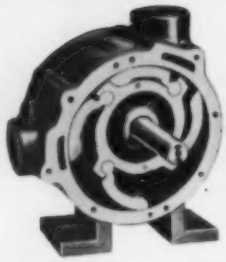
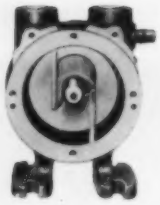


Metal Vanes take up their own wear



**4-VANE TYPE.** Vacuums to 20" Hg.; pressures to 15 lbs.; displacement to 162 c.f.m. Vanes hinged to pistons maintain continuous sealed contact with cylinder walls by centrifugal force. Small pistons, large air chambers, greater capacity.

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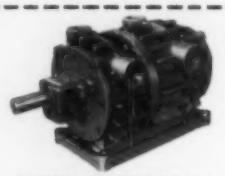

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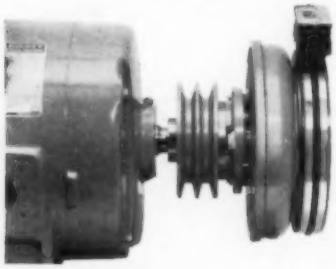

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addresses, information about trade associations, proprietary names, trade marks. A feature providing a useful reference for buyers not fullly conversant with British product terms, is the French, German and Spanish glossaries. These give translations of every product term used in the main buyers' guide.

## Conference on Welding Engineering

***US Army Engineer Research and Development Laboratories. Published by US Dept of Commerce, Office of Technical Services, PB 131739. 462 pp, 8 x 10. $6.***

Although this report on government-sponsored research covered the broad topic of welding, it included many aspects of design. About a quarter of the 35 papers have substantial design content. These included topics on: design of welded hydraulic structures, welding and arc cutting aluminum alloys, evaluation of welded structures, steel castings in weldments, welded design for vibration control, and welded aluminum failures, notch toughness of welded material, design and fabrication of welded aircraft parts. Of the remaining papers most had some design information but it was scant.

This report is worth its price if one of the above topics will help solve specific problems.

## Proceedings of the National Electronics Conference, Volume 13

***National Electronics Conference, Inc, 84 E Randolph St, Chicago 1, Ill. 9 x 6, 1066 pp. $7.50.***

This meeting was held in Chicago in October 1957. The proceedings include papers on transistor circuits, communications, servos, semiconductors, microwaves, components, electron tubes, magnetic amplifiers, instrumentation, and many types of circuit analysis.

## Basics of Digital Computers Volumes 1, 2, 3

**JOHN S MURPHY.** ***John F Rider Publisher Inc, 116 W 14th St, New York 11. 6 x 9, 116 pp, 133 pp and 136 pp. $6.95 per set.***

This is a 3-volume picture-book course which leaves no stone unturned from the extremely simple basics (early thoughts on computers) to data processing systems. At no point does the reader need to understand electronics or higher mathematics, yet the subject of computers is covered sufficiently to help the potential user understand and make decisions regarding any available computer.

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## English-Russian, Russian-English Electronics Dictionary

***Dept of the Army. McGraw-Hill Book Co, Inc, 330 W 42nd St, New York 36. 6 x 9, 952 pp. $8.***

Here is a comprehensive dictionary in the fields of electronic theory and applications. Translates about 22,000 Russian terms and abbreviations into English and 25,000 terms from English into Russian. The dictionary was compiled from all modern sources available in the US, USSR, and UK—including many terms obtained from Soviet factories, research institutions, and individual scientists.

Russian verbs are given in both imperfective and perfective forms; peculiar Soviet terms which, strictly speaking, have no equivalent in Western terminology are explained; terms having two spellings are given in both

(Continued on page 93)

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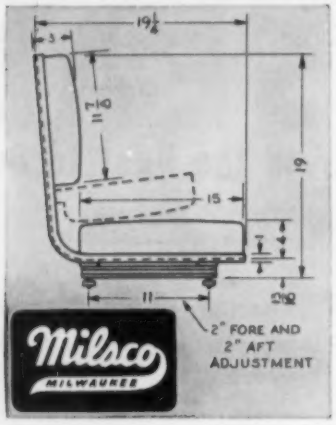


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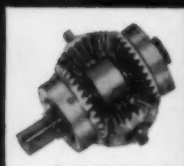

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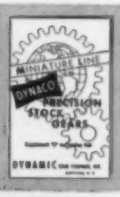


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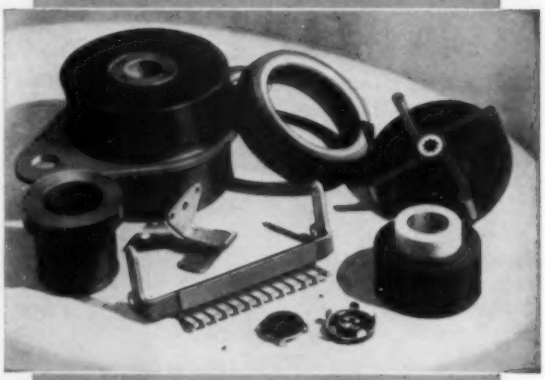

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forms; and an extensive cross-reference system is provided. No effort is made, however, to teach Russian or even to indicate pronunciation of the words defined. Bibliography includes list of sources from which electronic terms were obtained.

## The Junction Transistor and its Applications

*E WOLFENDALE, Editor. MacMillan Co, 60 Fifth Ave, New York 11. 6½ x 9½, 390 pp. $7.50.*

A research team of nine European physicists and engineers have put together a book that tells the story of the transistor from the physics of semiconductors to their application in typical circuits. Although separate sections have been authored by a specialist in that topic, the book is not simply a collection of unrelated technical papers—each chapter is based on information in previous chapters and each expands the student's grasp of circuits and fundamentals. One chapter early in the book is devoted to transistor equivalent circuits and they are used heavily throughout to analyze each circuit as it is introduced. Other typical chapters are High-frequency Amplification, Sinusoidal Oscillators, Nonlinear Circuits, and a rather over-long treatment of Transistor DC Converters (considering that converter circuits are relatively nonfundamental).

## Battery Engineering Manual

*Burgess Battery Co, Freeport, Ill. 9½ x 6, 97 pp. $1.*

The first seven pages are devoted to good basic information on various dry cell battery types as designated by ASA. Tables include ASA standard tests plus examples showing how to select batteries. The remainder of the book gives pictures, curves and performance of all batteries made by Burgess.

## Introduction to Electromagnetic Fields

*SAMUEL SEELY, McGraw-Hill Book Co, 330 W 42nd St, New York 36. 9 x 6, 308 pp. $8.50.*

The text material is divided into six related major areas: current-flow fields, static-electric fields, static-magnetic fields, dynamic fields, Maxwell's equations, electromagnetic phenomena. A previous knowledge of calculus and an

(Continued on page 95)

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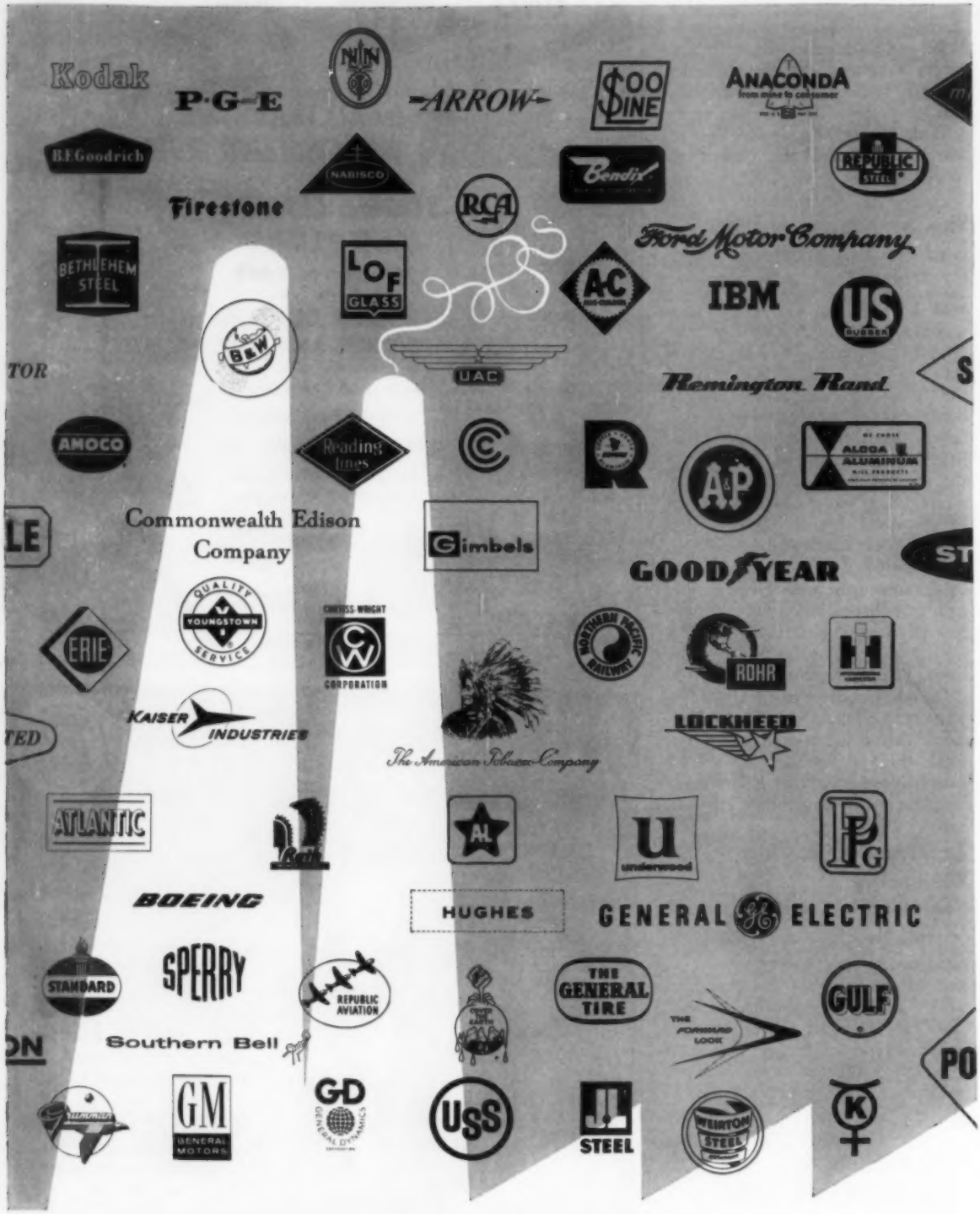


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understanding of the important concepts of classical mechanics is needed. From this point all derivations and explanations are contained within the text.

Basic topics covered include such elementary theorems as Coulomb's Law. The more complex Poisson and Laplace equations are also given. Other topics covered are conductors, dielectrics, capacitors, current fields in free space, magnetic effects of iron, electromagnetic induction, and a summary of vector formulas. Problems are given at end of each chapter.

## Study of Tubing for Aircraft Hydraulic Systems

**CONRAD H COOKE, RONALD D STOUFFER,** ***Wright Air Development Center, Wright-Patterson Air Force Base, Ohio. 10½ x 8, 103 pp. $3.***

This is a study to determine limitations of coiled stainless tubing as replacement for hydraulic hose. Numerous curve illustrations and actual examples are given to identify problems in bending, torsion, hydraulic pressure, flattening, fatigue, wall thickness, clamping, fittings, vibration, flexibility, materials, etc. Bibliography and lists of test reports are included.

## High Temperature Hydraulic Fluid

***Development Status and Engineering Data, ASTIA Document AD 131009*** **GEORGE BAUM, ROBERT J BENZING** ***Wright Air Development Center, Wright-Patterson Air Force Base, Ohio. Order from ASTIA Document Service Center, Knott Building, Dayton 2, Ohio. 10½ x 8, 36 pp. $1.25.***

This report was prepared by the lubricants section of the Materials Laboratory. It is essentially a review

(Continued on page 96)

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Fast . . . economical, GRC's exclusive automatic machines insert elements in zinc alloy die castings . . . in thermoplastic moldings, assure uniformity, eliminate assembly . . . make possible entirely new designs . . . cut labor and costs.

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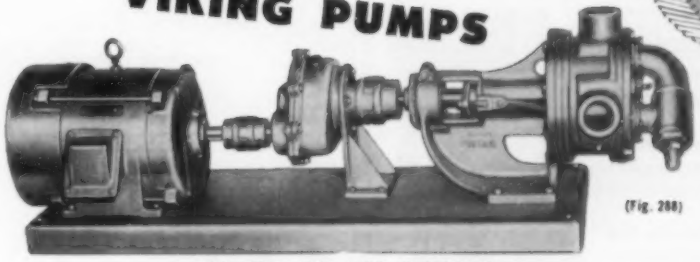

(Fig. 288)

35 - 50 - 90 - 150 G.P.M. Sizes

Addition of helical gear reductions makes Viking heavy-duty pumps more compact. Five gear reductions, easily interchanged, permit a wide range of pump speeds for handling thick or thin liquids. Gears run in a bath of oil, making quiet operation. Reducers are self-supported, not hung on pump or motor shaft.

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*See Our Catalog in Sweet's Product Design File*



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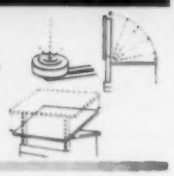
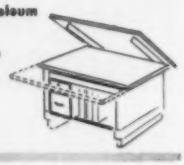


Reference desk has linoleum covered pull-out top for "sit-under" comfort . . . full width plan drawer, tool drawer with tray and lock, deep file drawer . . . generous bookshelf.



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HOOPSTON, ILLINOIS

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of high-temperature hydraulic fluid development from 550 to 700 F and low temperature development from 0 to −65 F. Covers organo-silicates disiloxanes, silicones, mineral oils and silanes. The available data on properties of these research fluids important to hydraulic system design are reported. These data include the following: viscosity-temperature, density-temperature, thermal stability, data for heat transfer calculations, compressibility, vapor pressure, and flammability measurements.

Design data on −65 F to 400 F-type fluids obtained by industry and the military services is compiled and reported.

# Current Reprints

While the supply lasts, single copies of the following reprints are obtainable by using the Reader Service Card.

**Linkages by Graphical Synthesis**

Design of 4-bar linkages to generate specific functions. Feb 2 Circle E 65

**Product Design at −300 F**

Planning for products that must handle liquified-air gases. Feb 2 Circle E 64

**Solution by Analogy**

What makes analog computers different from digital types? Jan 26 Circle E 63

**Roll Cams—Stop and Go on Demand**

Graphical method for designing simple mechanisms that give a prescribed motion when triggered. Jan 19 Circle E 62

**Which Fhp Motor for the Job?**

Applications and costs charted for a simpler way to pin down the right electric motor. Jan 19 Circle E 61

**With What Do the Russians We'd?**

Latest Soviet techniques—electro-slag, submerged-arc, and stored-energy welders, Jan 19 Circle E 60

**Engineer Salary Surveys**

Engineers Joint Council says engineer salaries are up 13% since 1956. GE reports effect of higher living costs. Jan 5 Circle E 59

**Mixed-flow Impellers**

When air pressure requirements are too high for axial and too low for centrifugal fans. Jan 5 Circle E 58

**Carpet Plotting for Hi-temp Data**

Data sheet shows interaction of stress, strain and temperature. Jan 5 Circle E 57

(Continued on page 97)

*Frankly,*

*we're in the dark . . .*

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**Tired Metal**

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**Lovejoy**

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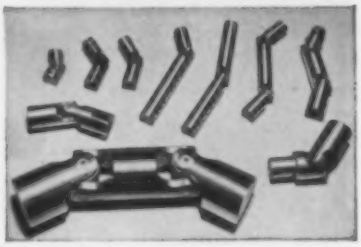
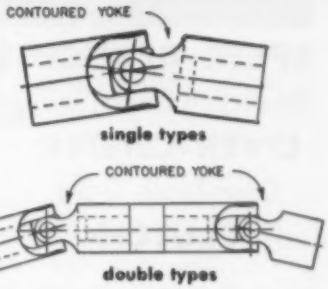
**INDUSTRY'S MOST COMPLETE LINE FOR EVERY SLOW SPEED APPLICATION**



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**Static Torque**—from 306 to 129,693 in.-lbs. at 12°, depending on size of joint.

**Horsepower Ratings**—.54 to 207 at 100 rpm.

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**Standard Specifications**—hub diameters ½ to 4" ... bores ¼ to 2" ... lengths (single) 2 to 10⅝", (double) 4 to 21¼". All specifications can be altered or special joints designed to individual requirements.

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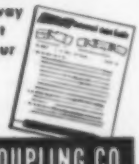
It's the quick and easy way to get the Universal Joint that is just right for your application. Request Bulletin 820.



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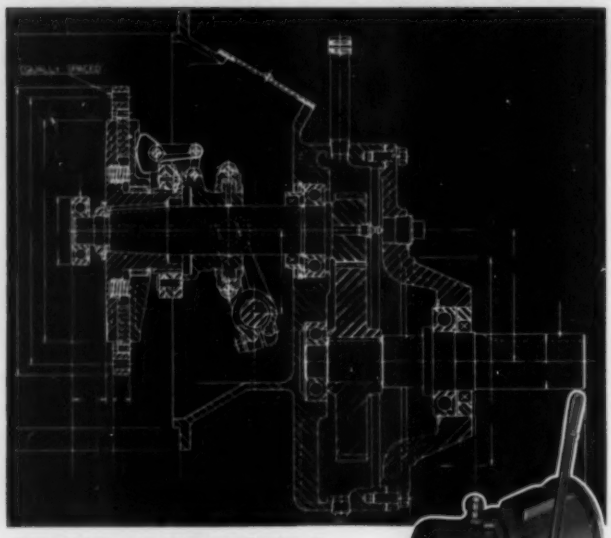

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## OVER-CENTER
Gear-Tooth Drive
## CLUTCH

ROCKFORD Speed Reducers incorporate a complete clutch power take-off and reduction gear assembled into one complete unit. They are suitable for the transmission of power from internal combustion engines where out-put shaft speeds required are lower than engine speeds. A heavy-duty, over-center clutch, with gear-tooth drive construction is used. Positive engagement or disengagement position is accomplished by mechanical action of toggle arrangement. Various reduction ratios are available. Standard S.A.E. housing sizes.

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Heavy Duty Spring Loaded

Oil or Dry Multiple Disc

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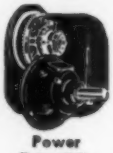
Power Take-Offs

Speed Reducers

ROCKFORD B-W BORG-WARNER

# CLUTCHES


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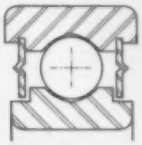
# EXTRA-THIN BEARING WITH BUILT-IN SHIELDS

- SAVES SPACE
- SIMPLIFIES ASSEMBLY
- CUTS MAINTENANCE COST

PHOTO shows bearing ACTUAL SIZE

SECTIONAL DRAWING is 3 TIMES SIZE



SIZE: 10.500" OD; 0.270" wide; 0.250" thick.
BALL DIAMETER: 0.125" ±.000025".
MATERIALS: Stainless steel.
MAXIMUM RUNOUT OF OUTER RACE: 0.0002" TIR.
STATIC LOAD CAPACITY: Radial, 4,630 lb.; axial, 13,200 lb.
TORQUE: 5 to 6 inch-ounces at 100 lb. axial load.

Standard bearings often impose limitations on production economy and freedom of design. These restrictions are often eliminated by *special* bearings, custom-engineered by ITI. For example –

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YOUR design problem might likewise be simplified or your product improved by ball or roller bearings of special section or configuration, heat resistance, corrosion resistance, ultra precision, or other unusual properties. We design and produce such bearings to individual requirements, in any size from ¼" ID to over 70" OD; and we invite your inquiries.

**FREE BULLETIN AFB-2** describes our work in this field – shows a wide variety of "specials" – tells about factors involved in special bearing applications. Write for it!

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ITI

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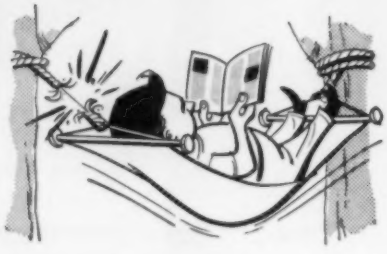
till you need
Dependability-



Get it *now*
with

# H & S Helical Gears

H & S Helical Gearing with overlapping tooth action is your ideal choice for power transmission on parallel shafts where speeds are high, where loads are high, and where smooth action is desired. Here's why —

- Correct machining of blank and accuracy of tooth generation reduce impact and increase load carrying capacity.
- Extra heavy rims, arms and hubs provide greater strength and stability.

H & S Helical Gears are available with diameters up to 125", 1 D.P. and 40" face.

It will pay you to learn more about the extra quality built into every H & S Gear. Send us your requirements. Quotations will be forwarded by return mail.

*Send for your free copy of H & S Gear Catalog No. 57.*

**THE HORSBURGH & SCOTT CO.**
**GEARS AND SPEED REDUCERS**
5112 Hamilton Avenue
Cleveland 14, Ohio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If you have a problem concerning high-heat protection of metal surfaces up to 4500°F, our Technical Service Department may be of valuable service to you. This service goes far beyond data sheets and specimens. Without cost or obligation, our engineers will analyze your requirements and make specific recommendations based on certified performance data. If necessary, we will visit your plant to confer with your engineers and study the problem first hand.

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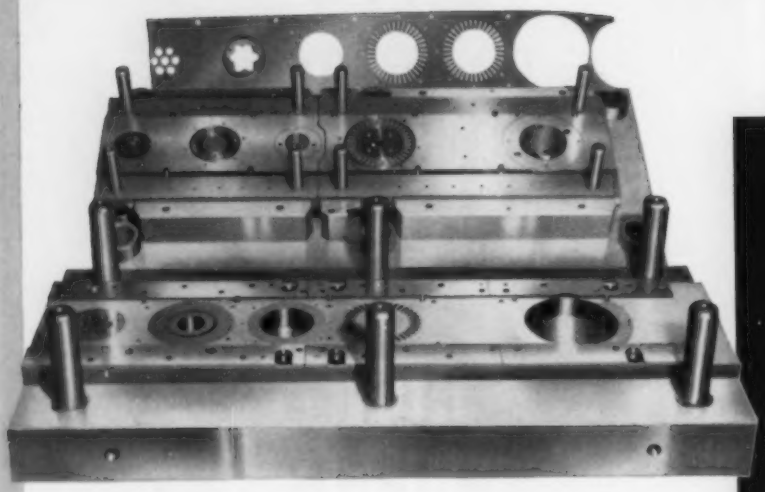

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WE WOULD BE PLEASED TO QUOTE
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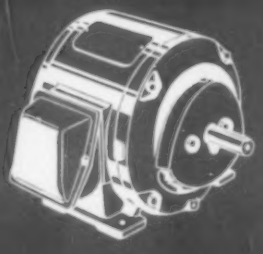

Reliance brings a permanent hush to fan motors. These Reliance Motors are quiet because they're sleeve bearing motors. The silence is permanent because of a new method of lubrication, Permawick.

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**RELIANCE** ELECTRIC AND ENGINEERING CO.

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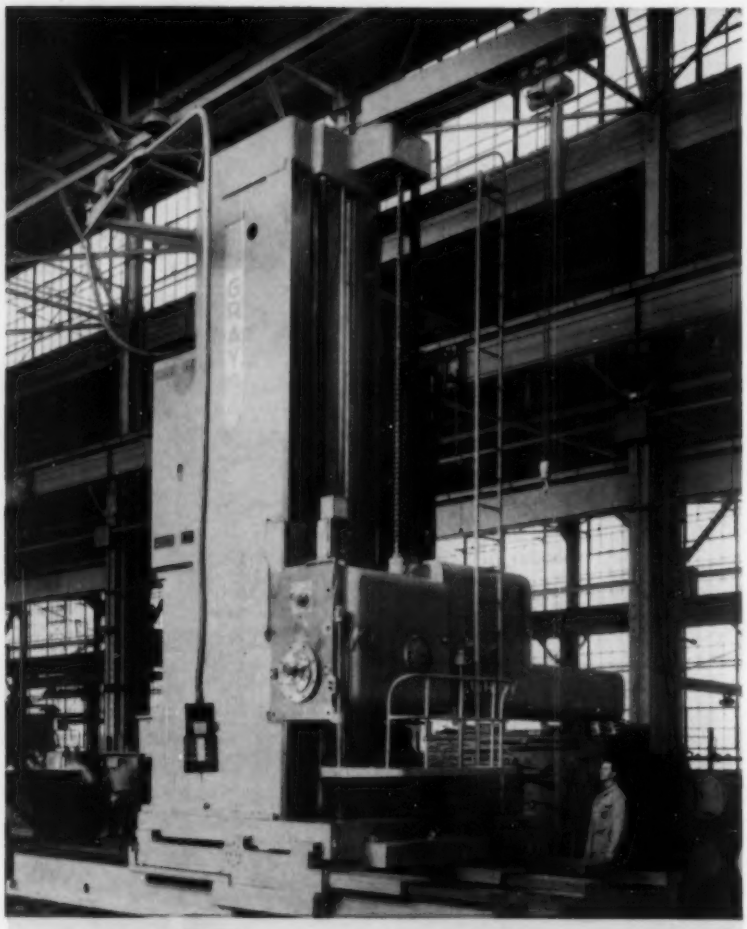
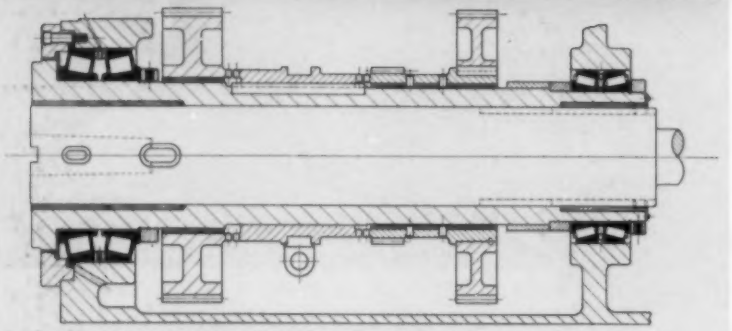
MASTER REEVES

# "We switched to TIMKEN® bearings to get greater accuracy and capacity," reports The G. A. Gray Company





How **THE G. A. GRAY COMPANY** mounts the spindle of its new Model 880-FC boring machine on Timken tapered roller bearings to get spindle accuracy, assure precision performance.

HERE'S a precision giant! It's The G. A. Gray Company's new 212½-ton Model 880-FC horizontal boring, drilling and milling machine. Weighing 425,000 lbs., it stands 27 ft. high, spans 76½ ft. in length. It can machine a block of metal 65 ft. long and 15½ ft. high—works with a precision of .00025". Yet one man operates the huge tool. To keep the spindle running accurately, Gray engineers switched to Timken® tapered roller bearings.

**Spindle held rigid.** Timken bearings hold the spindle in positive alignment. Their tapered design lets them take both radial and thrust loads in all combinations. And full-line contact between rollers and races gives Timken bearings extra load-carrying capacity.

**Heavy shocks no problem.** Rollers and races of Timken bearings are case-carburized to have hard, wear-resistant surfaces and tough, shock-resistant cores.

**Friction virtually eliminated.** Timken bearings are geometrically designed and precision-made to roll true. They roll the load. They practically eliminate friction, run smoother, longer with minimum maintenance. For extra quality-control, we even make our own steel. No other American bearing maker does. And you can get Timken tapered roller bearings with maximum runout of 75 millionths of an inch. For all these advantages, specify bearings trademarked "TIMKEN". The Timken Roller Bearing Company, Canton 6, Ohio. Canadian plant: St. Thomas, Ontario. Cable address: "TIMROSCO". Makers of Tapered Roller Bearings, Fine Alloy Steels and Removable Rock Bits.

*This symbol on a product means its bearings are the best.*

BETTER-ness rolls on **TIMKEN®** tapered roller bearings